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FEEDING AND MANAGEMENT INVESTIGATIONS AT THE UNITED STATES DAIRY EXPERIMENT STATION AT BELTSVILLE, MD.; 1932 REPORT

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INTRODUCTION

The facilities at the United States Dairy Experiment Station at Beltsville, Md., are devoted mainly to investigations that are planned to continue for many years. Certain phases of the various projects are completed from time to time; and as they are of considerable value to the dairy industry, it appears desirable to report them promptly rather than to await the completion of the entire investigations of which they are parts. It is found possible also from time to time to conduct certain shorter experiments in feeding and management of dairy cattle without interfering with the long-time projects. These short experiments cover a wide range of subjects and most of them are of a timely and practical nature. Several of these, along with certain phases of the longer investigations, are reported herein.

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This is the second report of experiments of this nature conducted at the Experiment Station at Beltsville, Md. The first was published in January 1932 as Miscellaneous Publication 130 (*14*).[1]

CALF-FEEDING INVESTIGATIONS

FEEDING COTTONSEED MEAL TO YOUNG CALVES

Many years ago five young calves were fed cottonseed meal at Beltsville. Three of them died, and the other two became so ill that the feeding of cottonseed meal was discontinued. Compounds of iron fed along with the meal to two of the calves failed to protect them. It was concluded from that experiment that cottonseed meal was an unsafe feed for young calves. Recent investigations at some of the State experiment stations have revived interest in the feeding of cottonseed meal to calves. At the Michigan station (*12*) calves 3 months old or older were fed cottonseed meal along with good roughage without any apparent harmful results. At the Oklahoma station (*8*) calves were fed cottonseed meal and prairie hay from 30 days of age until almost mature, and no harmful effects were noted.

The general plan of the investigation reported here was to substitute cottonseed meal for the regular grain mixture which consisted of 3 parts of ground corn, 2 parts of wheat bran, and 1 part of linseed meal. Some of the calves were given all the cottonseed meal they would eat. Others were fed only the quantity of cottonseed meal that they would normally have eaten of a grain mixture.

If the calf refused to eat the cottonseed meal or if the calf was in a pen with other calves, the cottonseed meal was mixed with the milk. Whole milk, skim milk, and a good grade of alfalfa hay were fed in accordance with the regular practice at Beltsville.

The cottonseed meal came from the southeastern part of the United States and was all from one shipment. When it arrived it was apparently in perfect condition, but after it had been in storage for a long time it lost some of its nutty aroma. Otherwise it appeared to be in good condition.

Detailed reports are presented on the feeding of all the calves. The weights of hay are approximations as the calves were not fed hay individually except when they were in small pens by themselves. Even then the refused hay was not recovered and weighed back. Post-mortem examinations were made by F. W. Miller, senior veterinarian and physiologist, Bureau of Dairy Industry and these are reported fully.

CALVES FED ORDINARY COTTONSEED MEAL

Table 1 shows the feeds consumed, and the weights of four calves fed ordinary cottonseed meal.

[1] Italic numbers in parentheses refer to Literature Cited, p. 50.

TABLE 1.—*Feed consumption and weights of 4 calves fed ordinary cottonseed meal*

Calf no. and feeding period beginning—	Length of feeding period	Whole milk	Skim milk	Cotton-seed meal	Alfalfa hay	Weight	
45-B:	*Days*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Date*	*Pounds*
July 9	10	80				July 8	58
July 19	10	80		1.0	2.0	July 18	68
July 29	10	80		3.0	2.0	July 28	72
Aug. 8	10	80		5.6	2.0	Aug. 7	82
Aug. 18	10		120	8.0	2.0	Aug. 17	93
Aug. 28	10		120	15.4	4.0	Aug. 27	105
Sept. 7	10		120	20.0	4.0	Sept. 6	118
						Sept. 16	130
49-B:							
Aug. 7	10	60				Aug. 6	50
Aug. 17	10	60		3.4	2.0	Aug. 16	60
Aug. 27	10	75		3.2	3.0	Aug. 26	63
Sept. 6	10	80		3.6	4.0	Sept. 5	68
Sept. 16	10	80		6.8	4.0	Sept. 15	82
Sept. 26	10	32	72	7.4	4.0	Sept. 25	96
Oct. 6	10		120	9.2	4.0	Oct. 5	105
Oct. 16	10		120	8.4	4.0	Oct. 15	113
Oct. 26	9		108	1.7	3.6	Oct. 25	120
14-B1:							
Mar. 10	10	72				Mar. 10	82
Mar. 20	10	80		.9		Mar. 20	97
Mar. 30	10	84		.3	8.0	Mar. 30	101
Apr. 9	10	100		.5	10.0	Apr. 9	116
Apr. 19	10	100		2.7	10.0	Apr. 19	121
Apr. 29	10	116		8.9	10.0	Apr. 29	140
May 9	10	120		10.0	10.0	May 9	155
May 19	3	36		3.0	3.0	May 19	173
215-B2:							
Aug. 14	10	35				Aug. 14	68
Aug. 24	10	68		4.3	4.0	Aug. 24	77
Sept. 3	10	91		7.8	4.0	Sept. 3	90
Sept. 13	10	68	40	8.9	6.5	Sept. 13	105
Sept. 23	10	12	128	11.1	5.8	Sept. 23	114
Oct. 3	9		136	9.3	5.5	Oct. 3	132

Calf 45-B, a grade Holstein male born July 8, 1930, was fed all the cottonseed meal it would eat beginning July 22, 1930. The alfalfa hay was of good color, grading no. 2 or better. The calf appeared normal and made good gains in weight up to the time of its death at 73 days of age. Autopsy showed a straw-colored liquid in the body cavities; the blood was a bright red and clotted slowly. This calf ate a total of 53 pounds of cottonseed meal and gained 72 pounds in weight in 70 days.

Calf 49-B, a grade Holstein male, twin with a female, born August 6, 1930, was fed in the same way as calf 45-B. Cottonseed-meal feeding started on August 20, 1930. A nasal discharge was noticed on October 13 and October 18. From October 25 to October 28 the calf was bloated much of the time and on at least two occasions fell over in a sort of faint. On October 30 it appeared normal but refused to eat the cottonseed meal. On November 3, one-half pound of the meal was mixed with milk and fed to the calf. Death occurred on the night of November 3, at the age of 89 days. Post-mortem examination showed bloat, blood a bright red and slow to clot and some hemolysis. This calf ate a total of 43.7 pounds of cottonseed meal and gained 70 pounds in 80 days.

Calf 14-B1, a grade Holstein male, twin with a male, born March 10, 1931, was fed cottonseed meal in the same way as the two preceding calves except that no skim milk was fed. When the calf was 45 days old the cottonseed meal was mixed with the milk, since the calf would not eat the meal when fed alone. Death occurred at

72 days. Post-mortem examination showed the following anatomical conditions: Muscles around shoulders filled with blood; muscles around thighs rather pale; considerable blood-tinged fluid and some straw-colored clots in lower part of the thoracic cavity; lungs moist, some blood and air in them; heart somewhat flabby and containing blood clots; liver light brown and soft; spleen very soft and when cut into, the parenchymatous tissue flowed out in a thick, red fluid; kidneys very soft and moist. This calf ate a total of 26.3 pounds of cottonseed meal and gained 91 pounds in 70 days.

Calf 215-B2, a purebred Holstein male, twin with a male, born August 14, 1931, was fed the same kind of cottonseed meal and in the same way as the three preceding calves. On October 1 the eyes were watery and dull, there was a discharge from the nostrils, and a catch in the inhalation. Death occurred on October 11 at the age of 58 days. Autopsy revealed the following anatomical changes: Large amount of a straw-colored fluid in the abdominal cavity; somewhat less of the same type of fluid in the thoracic cavity; peritoneum, intestines, and stomach inflamed; cord from the umbilicus to the urinary bladder contained pus; mild case of lobular pneumonia. This calf ate a total of 41.4 pounds of the meal and gained 64 pounds in 50 days.

CALVES FED AUTOCLAVED COTTONSEED MEAL

Some of the same lot of meal which was fed to the 4 preceding calves with fatal results was autoclaved under 15 pounds pressure for 30 minutes or more to destroy the toxicity of the gossypol. The material was then dried and ground and fed to four calves in the same way that the ordinary meal was fed. Detailed records of the feed and weights of these four calves are shown in table 2.

TABLE 2.—*Feed consumption and weights of 4 calves fed autoclaved cottonseed meal*

Calf no. and feeding period beginning—	Length of feeding period	Whole milk	Skim milk	Autoclaved cottonseed meal	Alfalfa hay	Weight	
403-B:	*Days*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Date*	*Pounds*
Aug. 5	10	30				Aug. 5	60
Aug. 15	10	62		2.8	3.2	Aug. 15	64
Aug. 25	10	80		7.0	4.0	Aug. 25	70
Sept. 4	10	88		7.0	8.1	Sept. 4	81
Sept. 14	10	98		5.6	6.9	Sept. 14	86
Sept. 24	10	100		12.0	7.6	Sept. 24	93
Oct. 4	10	68	50	10.0	23.4	Oct. 4	103
Oct. 14	10	2	118	12.8	19.7	Oct. 14	122
Oct. 24	10		140	14.2	28.0	Oct. 24	139
Nov. 3	10		140	16.0	27.7	Nov. 3	136
Nov. 13	10		140	16.8	40.2	Nov. 13	163
Nov. 23	10		140	16.8	42.9	Nov. 23	175
Dec. 3	10		140	20.0	38.4	Dec. 3	195
Dec. 13	10		140	22.0	38.9	Dec. 13	206
Dec. 23	10		140	24.6	43.0	Dec. 23	230
Jan. 2	10		140	30.0	41.6	Jan. 2	247
Jan. 12	10		140	30.0	43.7	Jan. 12	268
Jan. 22	10		140	30.0	91.0	Jan. 22	279
Feb. 1	10		140	30.0	94.6	Feb. 1	305
						Feb. 11	315
215-B1:							
Aug. 14	10	35				Aug. 14	71
Aug. 24	10	69		3.9	3.6	Aug. 24	65
Sept. 3	10	91		4.8	4.0	Sept. 3	76
Sept. 13	10	68	40	5.9	6.7	Sept. 13	84
Sept. 23	10	12	128	8.0	5.8	Sept. 23	97
Oct. 3	10		152	10.0	5.5	Oct. 3	115
Oct. 13	10		160	13.1	10.0	Oct. 13	131

TABLE 2.—*Feed consumption and weights of 4 calves fed autoclaved cottonseed meal*—Continued

Calf no. and feeding period beginning—	Length of feeding period	Whole milk	Skim milk	Autoclaved cottonseed meal	Alfalfa hay	Weight	
						Date	
215-B1—Continued.	*Days*	*Pounds*	*Pounds*	*Pounds*	*Pounds*		*Pounds*
Oct. 23	10		160	14.0	19.7	Oct. 23	145
Nov. 2	10		160	15.4	21.2	Nov. 2	146
Nov. 12	2		32	3.2	3.9	Nov. 12	162
46-B:							
Aug. 29	10	34				Aug. 29	87
Sept. 8	10	72		4.4	3.6	Sept. 8	
Sept. 18	10	88		7.8	6.0	Sept. 18	102
Sept. 28	10	73	50	9.8	6.1	Sept. 28	108
Oct. 8	10	8	132	10.8	20.9	Oct. 8	125
Oct. 18	10		154	13.6	20.5	Oct. 18	143
Oct. 28	10		160	15.0	19.1	Oct. 28	155
Nov. 7	10		160	16.0	21.1	Nov. 7	164
Nov. 17	10		160	16.0	22.3	Nov. 17	181
Nov. 27	10		160	18.4	32.3	Nov. 27	194
Dec. 7	10		160	20.0	39.2	Dec. 7	213
Dec. 17	10		160	23.6	40.3	Dec. 17	230
Dec. 27	10		160	27.0	42.8	Dec. 27	252
Jan. 6	10		160	30.0	41.5	Jan. 6	270
Jan. 16	10		160	30.0	43.7	Jan. 16	282
Jan. 26	10		160	30.0	44.7	Jan. 26	305
Feb. 5	7		112	21.0	31.8	Feb. 5	326
						Feb. 11	337
43-B:							
Sept. 1	10	33				Sept. 1	73
Sept. 11	10	70		5.0	4.0	Sept. 11	
Sept. 21	10	82		8.0	4.3	Sept. 21	73
Oct. 1	10	112	60	10.0	6.0	Oct. 1	93
Oct. 11	10	4	136	11.6	4.0	Oct. 11	112
Oct. 21	10		156	14.0	4.8	Oct. 21	128
Oct. 31	10		160	15.0	5.5	Oct. 31	148
Nov. 10	10		160	16.0	20.3	Nov. 10	154
Nov. 20	10		160	16.0	22.9	Nov. 20	
Nov. 30	10		160	19.6	20.2	Nov. 30	190
Dec. 10	10		160	20.8	23.7	Dec. 10	202
Dec. 20	10		160	24.0	38.2	Dec. 20	214
Dec. 30	10		160	28.8	42.4	Dec. 30	236
Jan. 9	10		160	30.0	42.4	Jan. 9	254
Jan. 19	10		160	30.0	43.6	Jan. 19	268
Jan. 29	10		160	30.0	45.1	Jan. 29	285
Feb. 8	4		64	12.0	18.1	Feb. 8	300
						Feb. 11	316

Calf 403-B, a purebred Jersey male born August 5, 1931, was slaughtered February 12, 1932, at the age of 191 days. Except for an abscess which developed at the side of the tail setting in November 1931, this calf appeared normal at all times, a condition confirmed by post-mortem examination. Most of the cottonseed meal was fed mixed with the milk. This calf ate a total of 306.8 pounds of autoclaved cottonseed meal and gained 255 pounds in weight in 190 days.

Calf 215-B1, a purebred Holstein male, twin with calf 215-B2 that was fed the ordinary cottonseed meal, was born August 14, 1931. On October 30 the calf became stiff, and the ankles of the hind legs were slightly cocked. Stiffness persisted until death on November 14 at the age of 92 days. On November 12 the calf had a convulsion in which it continued to struggle instead of lying in a faint as some of the other calves had done. Autopsy showed a cheesy, gassy curd in the abomasum; and very little roughage in the rumen and almost none in the intestines. The mucous membrane of the rumen scraped off easily. This calf ate 78.3 pounds of the autoclaved meal in 92 days and gained 91 pounds in weight in 90 days. Its twin brother ate 41.4 pounds of the ordinary meal and died in 58 days.

Calf 46-B, a grade Holstein male born August 29, 1931, was slaughtered February 12, 1932, at the age of 167 days. This calf appeared to be normal at all times. Post-mortem examination also showed it to be normal. In the 167 days it ate 293.4 pounds of the autoclaved meal and gained 250 pounds in weight.

Calf 43-B, a grade Holstein male born September 1, 1931, was slaughtered February 12, 1932, at the age of 164 days. This calf appeared normal at all times, although post-mortem examination showed some yellow fluid in the abdominal cavity and in the heart sack. In the 164 days it ate 290.8 pounds of the autoclaved meal and gained 243 pounds.

The data presented so far show that cottonseed meal will kill young calves if fed to them in considerable quantities, but that autoclaving the meal renders it less dangerous. Probably the constituent of cottonseed meal that is the most important agent in killing the calves is gossypol, which is known to be a poison and to be rendered nonpoisonous by autoclaving. Since 1 of the 4 calves fed the autoclaved meal died, cottonseed meal possibly lacks something essential to perfect nutrition, or the excess of protein in the ration may have been harmful.

Some of the same lot of cottonseed meal fed to these calves was sent to the Oklahoma Agricultural Experiment Station. Feeding experiments in which this cottonseed meal, as well as other meal obtained locally, was fed in about the same amounts as at Beltsville confirmed the results reported above with both ordinary and autoclaved meal (*9*). The fact that calves previously fed on cottonseed meal at the Oklahoma station had not been affected adversely is explained by the smaller quantities fed.

FEEDING COTTONSEED MEAL TO OLDER CALVES

Calf 213-B, a purebred Holstein male, was fed ordinary cottonseed meal from the same lot that was fatal to young calves. The feeding began when the calf was 159 days old and lasted for 166 days; 419 pounds of meal was fed. The calf increased in weight from 304 pounds to 645 pounds in 160 days. The rest of the ration consisted of skim milk and alfalfa hay. No signs of injury were manifested at any time.

Calf 2-B, a grade Holstein male 90 days old and weighing 191 pounds, was fed the same kind of cottonseed meal for 267 days, when he was slaughtered. The calf consumed 702 pounds of meal and gained 479 pounds in weight in the 267 days. He appeared perfectly normal at all times. A post-mortem examination, however, showed a yellow fluid in the abdominal cavity and in the heart sack.

So far as external appearances are concerned, these results are in agreement with those obtained at the Michigan Agricultural Experiment Station, mentioned previously. They are also what might have been expected in view of the results of feeding cottonseed meal to yearling heifers at the Pennsylvania Agricultural Experiment Station (*3*).

Two other calves (54-B and 14-B2) that had received linseed meal until they were 122 days old were fed ordinary cottonseed meal.

Calf 54-B had a convulsion the first day it was fed cottonseed meal and died after 53 days of such feeding. Autopsy revealed the following: Muscles pale; much dark blood in neck; lungs pink; kid-

neys black on surface, dark red on inside; heart distended and light in color. In the 53 days this calf consumed 424 pounds of skim milk, 81.6 pounds of cottonseed meal, and 195 pounds of alfalfa hay. It weighed 195 pounds at the beginning and 165 pounds at the end of the feeding period, having lost 30 pounds.

Calf 14-B2 was apparently normal at the time of changing from linseed meal to cottonseed meal. It died in 106 days. This calf had appeared a little sluggish for several weeks, although its appetite remained good until the day before its death. Autopsy showed a straw-colored fluid in the abdominal cavity; kidneys and liver enlarged; kidneys, liver, and spleen soft and full of blood; gall bladder inflamed, walls thickened and edema in the region of the bladder and bile duct. This calf in the 106 days consumed 316 pounds of whole milk, 1,144 pounds of skim milk, 229.8 pounds of cottonseed meal, and 633 pounds of alfalfa hay. It gained 140 pounds in weight, increasing from 254 to 394 pounds.

The fact that these 2 calves died and the other 2 thrived would lead one to believe that the previous feeding of linseed meal had been detrimental.

FEEDING OLD-PROCESS LINSEED MEAL TO YOUNG CALVES

In order to obtain additional information on the causes of the cottonseed-meal injury, linseed meal was fed to a number of calves. Unlike cottonseed meal, linseed meal is not known to contain any toxic substance. It was thought that if calves thrived on linseed meal the results would support the view that the toxic substance in cottonseed meal was responsible for the deaths of the calves fed that. On the other hand, if the calves should die when fed linseed meal, it would have to be assumed that some agent other than the toxic substance of cottonseed meal was responsible for the cottonseed-meal injury. All the calves in the experiment were grade Holstein males. Table 3 shows the total feeds consumed and the body weights.

TABLE 3.—*Feed consumption and weights of calves fed old-process linseed meal*

Calf no.	Days fed	Whole milk	Skim milk	Linseed meal	Alfalfa hay	Birth weight	Final weight	Gain in weight
	Number	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
54-B	122	321	1,392	141.8	252	75	195	120
14-B2	122	960	408	163.1	142	75	254	179
58-B	53	272	256	31.0	25	71	96	25
21-B	130	282	1,086	111.2	215	72	235	163
44-B	110	666	382	90.4	74	67	175	108
50-B	183	255	2,336	278.4	672	81	307	226
2-B	180	256	2,272	305.9	423	91	392	301

Calf 54-B, born March 6, 1931, was fed old-process linseed meal until it reached the age of 122 days. This calf was very stiff and excitable on April 13, but by May 1 it had apparently recovered and seemed to be entirely normal. When the calf was 122 days old cottonseed meal was substituted for the linseed meal. On the day of the change the calf had a convulsion. The feeding of linseed meal may have produced such a condition that only a little of the cottonseed meal was required to cause convulsions.

Calf 14-B2, a twin of calf 14-B1 that was fed raw cottonseed meal (p. 3), was born March 10, 1931. This calf became stiff and excit-

able on April 29, but apparently was all right again in a few days. When the calf was 122 days old, ordinary cottonseed meal was substituted for the linseed meal. The twin brother of this calf died at the age of 72 days after eating 41.4 pounds of ordinary cottonseed meal.

The history of these two calves, 54-B and 14-B2, after linseed meal was discontinued has been discussed under Feeding cottonseed meal to older calves (p. 6).

Calf 58-B, a grade Holstein male born November 21, 1931, was fed linseed meal in the same way as the two preceding calves. On December 25 it ran bawling about the pen and fell down in a sort of convulsion after bumping into the side of the pen. On January 3, 1932, it had a similar but more severe attack, and died on January 14, 1932, at the age of 54 days.

Autopsy revealed the following: Ribs bent easily and to a great extent before breaking, all organs very moist, about a quart of grayish-yellow fluid in the abdominal cavity, considerable gas in the abomasum, pneumonia in the lower points of the anterior lobes of the lungs. Cause of death was diagnosed as autointoxication.

Calf 21-B, a grade Holstein male born October 14, 1931, was fed linseed meal until February 21, 1932, a period of 130 days. At about 80 days of age it began to refuse the linseed meal even when the meal was mixed with the milk. It was slaughtered on February 21, and the post-mortem examination showed it to have been a normal calf.

Calf 44-B, a grade Holstein male born December 24, 1931, was fed linseed meal until April 13, 1932, a period of 110 days. This calf also began refusing the linseed meal at about 80 days of age. When the calf was slaughtered on April 19 a straw-colored fluid was found in the abdominal cavity, and there was some enteritis.

Calf 50-B, a grade Holstein male born April 3, 1932, was fed linseed meal for 183 days without any outward indication of injury, and was slaughtered. Post-mortem examination showed that the carcass and organs were normal except for a small amount of yellowish edema along the blood vessels of the mesentery.

Calf 2-B, a grade Holstein male born July 9, 1932, was fed linseed meal for 180 days. This calf made good gains in weight and appeared normal at all times. Post-mortem examination also showed all organs to be normal.

The abnormalities exhibited by some of the calves fed linseed meal show that the ration of milk, alfalfa hay, and linseed meal did not provide perfect nutrition. There can be no doubt, however, that the calves fed linseed meal did better than those fed ordinary cottonseed meal. It appears, therefore, that cottonseed meal contains some substance that linseed meal does not, which is detrimental to the calves.

FEEDING YOUNG CALVES ON MILK FROM COWS RECEIVING COTTONSEED MEAL

The purpose of this investigation was to find out whether the injurious properties of cottonseed meal were passed on into the milk. The North Carolina Agricultural Experiment Station (*6, p. 41*) reports that one of a pair of twin calves, dropped by a cow that was fed cottonseed meal and hulls, was fed milk from the dam and failed to thrive while the other twin was fed milk from a cow on a normal ration and grew well.

Two calves were fed milk from cows that were each eating 10 pounds of cottonseed meal a day, along with alfalfa hay. Four calves were fed milk from cows that were each eating 10 pounds of cottonseed meal a day, along with wheat straw. All these calves were grade Holstein males except one (no. 79), which was a grade Holstein heifer from one of the cows that was being fed cottonseed meal and wheat straw. They received a good grade of alfalfa hay and the usual grain mixture composed of 3 parts of ground corn, 2 parts of wheat bran, and 1 part of linseed meal. The feed consumption, the weights, and other data for 5 of the 6 calves are shown in table 4.

TABLE 4.—*Feed consumption and weights of 5 calves fed milk from cows receiving cottonseed meal*

Calf no.	Days fed	Milk from cows fed—	Milk	Grain	Hay	Birth weight	Final weight	Gain in weight
	Number		*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
213-B	130	Cottonseed meal and alfalfa	1,320	231	253	90	232	142
2-B	96	do	1,070	102	170	86	203	117
79	130	Cottonseed meal and straw	1,640	180	253	67	227	160
27-B	25	do	196			80	[1] 91	11
36-B	150	do	1,717	231	350	95	295	200

[1] Weight at the age of 20 days, 5 days before death.

All the calves listed in table 10 thrived except 27-B. This calf died of enteritis at the age of 25 days. Shortly before death it had a convulsion manifested by forceful extension of the legs, champing of the jaws, and occasional bawling. It assumed a sitting posture, indicative of pain in the abdomen.

Another calf, 50-B, not listed in the table, was fed milk from cows receiving cottonseed meal and straw until it was 30 days old. Then, as the cows that were receiving cottonseed meal and straw went dry, the calf was fed milk from the cows receiving cottonseed meal and alfalfa hay. This calf at about 70 days of age began to develop symptoms which were interpreted as being typical of vitamin A deficiency. These were stiffness, watery eyes, growths on the corneas of both eyes, nasal discharge, and clonic convulsions. The calf died at the age of 109 days. Autopsy showed the presence of a hair ball in the rumen which appeared to have impeded the passage of food, especially roughage, into the abomasum, as the abomasum contained only fluid and milk curd.

While the data are insufficient to be conclusive, it can be said that milk from cows fed cottonseed meal is harmless in some if not all cases. It appears that the death of one of the calves, 50-B, and possibly that of the other calf, 27-B, was due to causes other than the kind of milk.

FEEDING COTTONSEED MEAL AND WHEAT STRAW TO DAIRY COWS

A number of attempts have been made at Beltsville to produce the so-called cottonseed-meal injury in dairy cows, for the purpose of observing the symptoms and trying different remedies. All these attempts have failed. Cows have been fed cottonseed meal along with different roughages like pasture grass, alfalfa hay, timothy hay, and corn silage. None of this roughage would be called poor, and some of it was very good. With the idea that the roughage fed in the

previous trials had been good enough to protect the cows, another attempt to bring about cottonseed-meal injury was made by feeding only wheat straw for the roughage part of the ration.

Two grade Holstein cows were selected for the test. At the time the feeding of cottonseed meal started, cow A-30 was 5 years old and 151 days along with calf; cow A-38 was 4 years old and 88 days along with calf. Cow A-30 was fed 10 pounds of cottonseed meal a day; cow A-38, 6 pounds a day. Both had all the wheat straw they would eat. Cow A-30 gave birth to a normal calf after a gestation period of 279 days. Cow A-38 gave birth to a dead calf after a gestation period of 270 days. Death occurred during parturition, as the calf was observed to be alive a short time before delivery. The head was doubled back and the fetus had become twisted around in the uterus in such a way as to shut off the circulation of blood. After cow A-38 calved she was given 10 pounds of cottonseed meal a day, the same as cow A-30. Both cows were continued on these rations for a period of 534 days. Cow A-30 ate 5,299 pounds of cottonseed meal and 11,054 pounds of wheat straw; cow A-38 ate 4,550 pounds of cottonseed meal and 8,496 pounds of straw.

Photographs taken of these two cows 34 days and 526 days after the feeding of cottonseed meal started are shown in figures 1 and 2. Although both cows became rather thin and sluggish and gave much less milk than they would have given on a good ration they continued to eat the cottonseed meal, and at no time did either of them become sick or exhibit symptoms of cottonseed-meal injury. Their health appeared to be affected only in regard to oestrum and conception. After freshening, cow A-30 came in heat at irregular intervals, cow A-38 not for 6 months and then only after receiving 100 cc of cod-liver oil a day for 82 days. Thereafter, she came in heat regularly. It cannot be said definitely that cod-liver oil was responsible for this result. Both cows were bred 10 times. Cow A-30 was bred 7 times while she was on the cottonseed-meal ration, and cow A-38 was bred 6 times. Cow A-30 was bred 3 times after being turned on pasture and cow A-38, 4 times. Post-mortem examination showed that neither was pregnant and that the genital organs of both were apparently normal.

In view of the excellent breeding record of the cows fed cottonseed meal at the Oklahoma station (*10*) and the favorable results secured at the Michigan station (*11*) when cottonseed meal was fed in comparison with linseed meal, it appears that the sterility of these two cows cannot be attributed to the cottonseed meal. Taking into consideration the data that have accumulated at the various experiment stations, it is evident that so far as dairy cows are concerned "cottonseed-meal poisoning" or "cottonseed-meal injury" does not exist under any ordinary conditions of feeding.

FEEDING SKIM MILK TO COWS AND HEIFERS

The low price of hogs and the necessity for reducing to a minimum the cash outlay for dairy-cattle feed has stimulated interest in the question of whether skim milk might not be fed to dairy cattle instead of to hogs.

Two grade Holstein cows, A-36 and A-37, were each given 4 gallons of skim milk a day beginning September 7, 1929. Each of these cows was yielding about 40 pounds of milk a day. Since neither would

drink the skim milk at first it was diluted with water and the diluted mixture given to them in place of water. Cow A-37 developed sufficient liking for the skim milk to drink it straight, but cow A-36 would not drink it undiluted. With both cows, however, the water bowls had to be taken out of the stalls and kept out in order to get them to drink the skim milk either diluted or straight. Cow A-36 was fed skim milk for only 16 days; cow A-37 for 34 days.

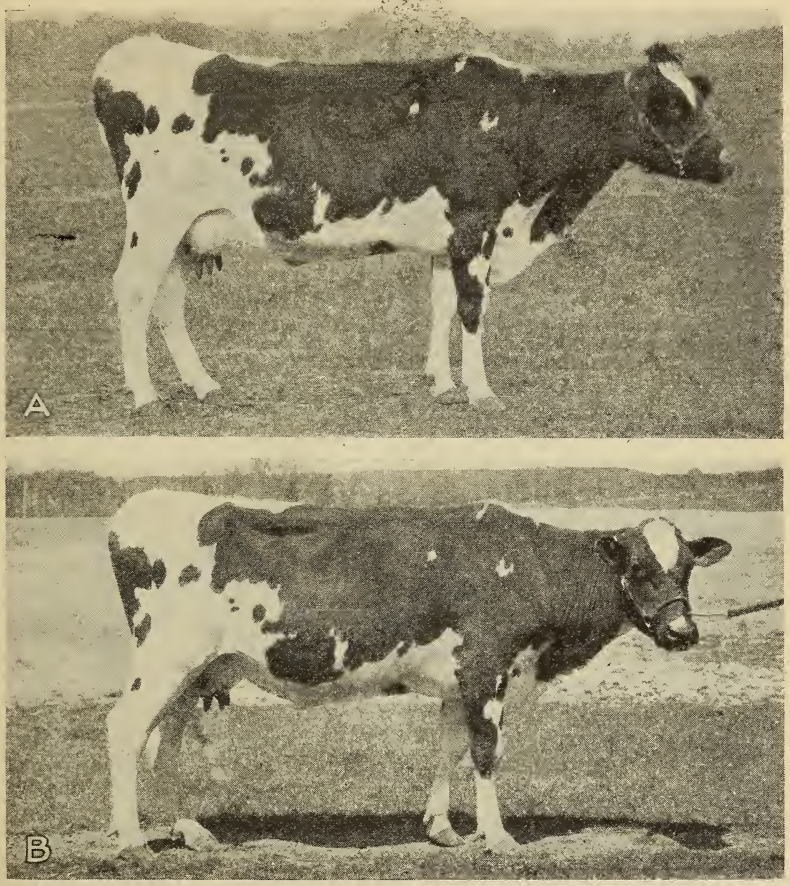

FIGURE 1.—Cow A-30 after being fed cottonseed meal and wheat straw for about 1 month (*A*) and 17 months (*B*).

On November 8, 1932, 35 registered and grade Holstein cows were offered warm skim milk individually. All refused. On the same date 14 Holstein heifers ranging in age from 16 to 24 months were offered warm skim milk. Four of them drank and three others tasted the skim milk. None of these heifers had received skim milk since they were 8 months old.

In an experiment beginning November 14, 1932, a group of 3 Jersey and 2 Holstein cows giving a total of about 100 pounds of milk a day was fed skim milk in the drinking water. The plan was to feed as much skim milk as would have been obtained from the milk yielded

by these same cows. Skim milk was added to the drinking water at the rate of 2 gallons the first day, 4 the second, 6 the third, and so on until 10 gallons were being added. The grain mixture was then changed from one containing 19 percent of protein to one containing 13 percent of protein, and the amount of grain given to the cows was reduced 11 pounds. Eighty-six pounds of skim milk were expected to take the place of 11 pounds of high-protein grain. Drinking water was withheld, but the cows had all the diluted skim milk they would

FIGURE 2.—Cow A-38 after being fed cottonseed meal and wheat straw for about 1 month (*A*) and 17 months (*B*).

drink twice a day. None of the cows developed a liking for the diluted skim milk, and they always drank it reluctantly. On December 7, 23 days after the experiment started, the feeding of skim milk was discontinued and the cows were given the same kind and quantities of grain that they had received previous to the experiment.

In order to compare the quantities of diluted skim milk that were drunk with the quantities of water drunk, weights of the diluted skim milk were taken for 3 days immediately preceding its discontinuance and the weights of water for 3 days immediately after the skim milk

was discontinued. The cows each drank an average of 67 pounds per day of the diluted skim milk, and 72 pounds of the water.

Table 5 shows the milk yield of these five cows during the last 10 days of the skim-milk feeding period and the yields for 10 days before and 10 days after the feeding period.

TABLE 5.—*Milk produced by 5 cows when on their regular ration, and when the high-protein concentrates were replaced by skim milk*

Cow no.	Milk produced when on—			Average of the two regular ration periods
	Regular ration (Nov. 4–13)	Skim-milk ration Nov. 27–Dec. 6)	Regular ration Dec. 20–29)	
	Pounds	*Pounds*	*Pounds*	*Pounds*
678	274.1	252.1	269.9	272.0
690	64.8	45.6	42.9	53.9
697	142.5	119.0	128.8	135.6
844	375.5	308.6	327.8	351.6
865	201.5	161.3	170.4	186.0
Total	1,058.4	886.6	939.8	999.1

The milk production declined sharply during the period of feeding skim milk. The difference between the average yield during the two 10-day periods on the regular ration and the yield during the last 10 days of feeding skim milk is 112.5 pounds in favor of the regular ration. The saving in high-protein grain was 110 pounds. In other words, the substitution of 860 pounds of skim milk for 110 pounds of high-protein grain resulted in the production of 112.5 pounds less milk.

It seems that the main difficulty in feeding skim milk to cows is its lack of palatability. The suggestion has been made that if skim milk were fed continuously from calfhood the cows might drink it more readily than when they have not been fed skim milk for several years. Fortunately, the Bureau of Dairy Industry already has some data relative to this subject. Thirty-four Holstein heifers at four of the bureau's field stations had been fed skim milk for extended periods. Eight of the 34 drank it at the age of 24 months. All the rest refused the skim milk before they had reached this age. The age at which they refused varied from 8 to 23 months. Most of them took the skim milk until they were over 1 year of age.

Skim milk can be utilized better by dairy cattle by extending the period of feeding skim milk to heifers than by feeding it to cows. Work done many years ago at the Connecticut (Storrs) Agricultural Experiment Station (*2*) and more recent investigations at the Minnesota Agricultural Experiment Station (*5*) support the findings reported here to the effect that skim milk is not a satisfactory feed for dairy cows.

THE DIGESTION OF GREEN GRASS AND HAY BY DAIRY COWS[2]

Work was undertaken to answer certain questions concerning the use of pasture grass as a feed for dairy cows. Certain unpublished theories or opinions have been advanced which need confirmation before they can be accepted. The particular claims upon which it was hoped that this investigation would provide information are as

[2] C. B. Parker, junior chemist, Bureau of Dairy Industry, did the analytical work.

follows: (1) Cows fed pasture grass as a sole ration do not digest their feed efficiently; (2) the feeding of hay along with grass is helpful in regurgitation of the feed for remastication; and (3) a green color of the feces indicates imperfect digestion.

COWS USED IN THE EXPERIMENT

The following are descriptions of the cows used in the feeding trials:

Cow 271, a registered Holstein, was 9 years old, fresh about 4 months, and yielded 29 pounds of milk a day in the first trial. She had been fed since freshening on chopped, artificially dried soybean hay exclusively. Later she was replaced by cow A-37, a grade Holstein, nearly 5 years old, dry, and about 8 months along with calf.

Cow A-43, a grade Holstein, was 3 years old, and yielded 20 pounds of milk a day in the first feeding trial and 19 pounds in the second.

Cow A-46, a grade Holstein, was 3 years old, and yielded 22 pounds of milk a day in the first trial, and 16 in the second.

The two latter cows had each recently completed a 365-day test record and were about 6 months along with calf.

PLAN OF DIGESTION TRIALS

In the first digestion trial, grass clippings and artificially dried soybean hay were fed. Cow 271 was fed all the artificially dried hay she would eat as the sole ration; cow A-46 was fed all the grass she would eat; cow A-43 was fed one half as much grass as A-46 received, and one third as much hay by weight as grass.

In the second trial, grass clippings and field-cured soybean hay were used. Since cow 271 failed to eat satisfactory quantities of this hay, she was replaced by cow A-37. The latter was fed field-cured hay in such amounts as she would eat, cow A-43 was fed grass only, and A-46 received a ration of both hay and grass. Each cow received 40 g of common salt every day in both trials.

For 10 days previous to each digestion trial all cows were fed the same kinds and quantities of feeds as they were fed during the digestion trials. The feces were collected for 7 consecutive days. In making the estimations of intake and outgo, a 2-day interval between ingestion and excretion was allowed. That is to say, the collection of feces was begun 2 days after the experimental feeding period started and continued for 2 days after the feeding period stopped.

The grass was mostly Kentucky bluegrass, from 2 to 4 inches high, and was cut from the lawn each afternoon with a lawn mower. A representative, aliquot sample was taken for chemical analysis, weighed, and dried to an air-dry condition. Each day a ration of grass was weighed out for each cow for that afternoon and for the following morning, the morning ration being stored either in a refrigerator or in some other cool place until feeding time.

Enough soybean hay for the entire experiment was selected, mixed, and sampled. The artificially dried soybean hay was made from plants that were cut at an immature stage of growth before any of the beans had hardened. The field-cured soybean hay was made from plants cut at a somewhat more mature stage. Although both these hays were raised at the Bureau of Dairy Industry station at Lewisburg, Tenn., they are not necessarily comparable, for they were raised in different years and on different fields.

Chemical analyses of the various feeds were made for the usual feed constituents as well as for calcium and phosphorus. Also, any

refused feed was weighed and analyzed for the same constituents when much of it was refused and it appeared different from the original feed offered the cows. As the refused grass appeared similar to the original grass, except in water content, it was analyzed for water only. The quantity of field-cured hay refused was very small, and the rejected material seemed to contain about the same proportion of leaves to stems as the original hay. In this case the refused hay was dried and its air-dry weight deducted from that of the air-dry hay offered to the cows.

Each morning between 9:30 and 10 o'clock the cows were exercised by walking a distance of about one fourth of a mile. An attendant was constantly on duty to collect any feces passed by a cow during the exercise period or when the cows were in the stable. Promptly at 10 o'clock each morning the feces collected from each cow in the preceding 24 hours were weighed, mixed, and an aliquot sample was taken for analysis. The sample was placed in a small covered pail, preserved with chloroform, and kept in a refrigerator. At the conclusion of the experiment the aliquot samples from each cow were mixed and portions were taken for nitrogen and moisture determinations. A portion was dried and analyzed for the other constituents.

An experiment conducted in this manner should furnish information on the digestion of the artificially dried hay, of the field-cured hay, of grass, and of a mixture of hay and grass. Although the data do not permit a direct comparison of the digestion of the artificially dried hay and the field-cured hay, because of the big difference in consumption of the 2 hays, they do afford an indirect comparison of the digestion of the 2 hays when fed along with grass. The relative digestibilities of green and dry feed cannot be estimated from the results of this work, because the green feed differed from the dry feed in both kind and maturity of crop. It is planned to make this matter the subject of a future experiment.

In addition, some information was obtained on the maximum quantities of grass that these cows would eat. A record was made also of the time spent by each cow in remasticating her feed during two 24-hour periods in each digestion trial.

RESULTS OF DIGESTION TRIALS

The results of the two digestion trials are shown in tables 6, 7, and 8. Table 6 gives the composition of the feeds and feces; table 7 shows the results of the first trial, and table 8 the results of the second trial.

TABLE 6.—*Composition (dry-matter basis) of the feeds fed to cows in 2 digestion trials, of the portions refused, and of the resultant feces*

FIRST DIGESTION TRIAL

Item	Dry matter	Protein	Ether extract	Nitrogen-free extract	Crude fiber	Calcium	Phosphorus
Feed:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Green grass	26.00	20.54	4.08	39.88	26.11	0.431	0.323
Dehydrated soybean hay	89.14	10.31	2.87	47.92	26.68	1.447	.145
Refused dehydrated hay	78.17	8.33	1.93	37.72	25.29	1.193	.138
Refused grass and hay	59.09	13.66	3.81	44.00	20.88	1.464	.196
Feces:							
Cow A-46, fed grass	9.60	17.08	4.79	33.44	21.25	1.010	.802
Cow A-43, fed grass and hay	17.00	11.94	3.88	29.12	30.47	2.100	.406
Cow 271, fed dehydrated hay	21.20	10.99	3.49	26.56	34.15	3.156	.240

TABLE 6.—*Composition (dry-matter basis) of the feeds fed to cows in 2 digestion trials, of the portions refused, and of the resultant feces*—Continued

SECOND DIGESTION TRIAL

Item	Dry matter	Protein	Ether extract	Nitrogen-free extract	Crude fiber	Calcium	Phosphorus
Feed:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Green grass	29.61	18.24	4.22	41.98	25.50	0.493	0.331
Field-cured hay	90.71	14.54	2.55	40.16	34.28	1.312	.390
Refused grass and hay	66.22	16.04	2.99	40.46	27.59	1.113	.356
Feces:							
Cow A-43, fed grass	10.40	13.94	6.63	32.88	20.86	.913	.808
Cow A-46, fed grass and hay	13.90	13.31	4.24	31.15	35.68	1.626	.655
Cow A-37, fed field-cured hay	17.60	12.21	1.14	28.58	45.91	3.386	.795

TABLE 7.—*Intake, outgo, and apparent digestibility of green grass, grass and dehydrated soybean hay, and dehydrated hay, first digestion trial*

Item	Total feed and total feces	Constituents of feed and of feces						
		Dry matter	Protein	Ether extract	Nitrogen-free extract	Crude fiber	Calcium	Phosphorus
Cow A-46, fed grass:								
Intake kilograms	204.42	53.15	10.92	2.17	21.20	13.88	0.229	0.172
Outgo do	152.67	14.66	2.50	.70	4.90	3.11	.148	.118
Net absorbed (digested) percent		72.4	77.1	67.7	76.9	77.6	35.4	31.4
Cow A-43, fed grass and dehydrated hay:								
Feed offered:								
Grass kilograms	105.50	27.43	5.63	1.12	10.94	7.16	.118	.089
Hay do	35.50	31.64	3.26	.91	15.17	8.44	.458	.046
Total do	141.00	59.07	8.89	2.03	26.11	15.60	.576	.135
Feed refused do	13.12	7.75	1.06	.30	3.41	1.62	.113	.015
Intake do	127.88	51.32	7.83	1.73	22.70	13.98	.463	.120
Outgo do	107.61	18.29	2.18	.71	5.33	5.57	.384	.074
Net absorbed (digested) percent		64.4	72.2	59.0	76.5	60.2	17.1	38.3
Cow 271, fed dehydrated hay:								
Feed offered kilograms	126.00	112.32	11.58	3.23	58.83	29.96	1.625	.163
Feed refused do	10.10	7.90	.66	.15	2.98	2.00	.094	.011
Intake do	115.90	104.42	10.92	3.08	55.85	27.96	1.531	.152
Outgo do	234.20	49.65	5.46	1.73	13.19	16.96	1.567	.119
Net absorbed (digested) percent		52.5	50.0	43.8	76.4	39.3	−2.4	21.7

None of the analyses shown in table 6 appear unusual except that of the dehydrated soybean hay. This hay was low in protein, considering that the soybean plants were harvested at an immature stage of growth, when they would normally be expected to be higher in protein than plants cut at a more mature stage. The phosphorus content, too, was very low, being less than one half that shown for soybean hay in Feeds and Feeding by Henry and Morrison (*6a, p. 736*). The field on which this hay was grown had considerable slope and had undergone some erosion. It is possible that the soil was deficient in phosphorus.

TABLE 8.—*Intake, outgo, and apparent digestibility of green grass, grass and field-cured soybean hay, and hay, second digestion trial*

Item	Total feed and total feces	Constituents of feed and of feces						
		Dry matter	Protein	Ether extract	Nitrogen-free extract	Crude fiber	Calcium	Phosphorus
Cow A-43, fed grass:								
Intake.....kilograms	200.64	59.41	10.83	2.51	24.94	15.15	0.293	0.197
Outgo.....do	167.96	17.47	2.44	1.16	5.74	3.64	.160	.141
Net absorbed (digested) percent		70.6	77.5	53.8	77.0	76.0	45.4	28.4
Cow A-46, fed grass and field-cured hay:								
Feed offered:								
Grass.....kilograms	105.00	31.09	5.67	1.31	13.05	7.93	.153	.103
Hay.....do	35.00	31.75	4.62	.81	12.75	10.88	.416	.124
Total.....do	140.00	62.84	10.29	2.12	25.80	18.81	.569	.227
Feed refused	5.29	3.50	.56	.10	1.42	.97	.039	.012
Intake.....do	134.71	59.34	9.73	2.02	24.38	17.84	.530	.215
Outgo.....do	152.85	21.25	2.83	.90	6.62	7.58	.345	.139
Net absorbed (digested) percent		64.2	70.9	55.4	72.8	57.5	34.9	35.3
Cow A-37, fed field-cured hay:								
Intake.....kilograms	53.25	48.30	7.02	1.23	19.40	16.56	.634	.189
Outgo.....do	117.71	20.72	2.53	.24	5.92	9.51	.702	.165
Net absorbed (digested) percent		57.1	64.0	80.5	69.5	42.6	−10.7	12.7

An examination of tables 7 and 8 shows a reasonably close agreement in the figures for the digestion coefficient or percentage digested, of each constituent of the ration of grass alone, fed cow A-46 in the first trial and cow A-43 in the second trial. The same can be said of the results of feeding dehydrated hay and grass together to cow A-43 in the first trial and field-cured hay and grass together to cow A-46 in the second trial. The ration of field-cured hay alone fed cow A-37, however, was digested somewhat better than that of dehydrated hay fed cow 271. This apparent difference in the results is to be attributed to the difference in the quantities of field-cured and dehydrated hay consumed rather than to the methods of curing the hay, as it is well-known that a small ration is more efficiently digested than a large one.

The intake of dry matter by the cow fed grass alone during the first trial was 53.15 kg (1 kg = 2.2046 pounds) and that by the cow fed grass and dehydrated soybean hay was 51.32 kg. In the second trial the consumption of dry matter by the cow fed grass alone was 59.41 kg, and that of the cow fed grass and field-cured soybean hay was 59.34 kg. These quantities are so nearly the same that any difference between the digestion of the ration of grass alone and the ration of grass and hay cannot be attributed to any difference in the intake of dry matter. The dry-matter consumption by the cow fed field-cured soybean hay alone in the second trial was 48 kg. This amount was probably not enough less than that consumed by the cows fed grass alone and hay and grass together to influence materially the coefficient of digestion. The cow fed the dehydrated soybean hay, however, consumed 104 kg of dry matter or almost twice as much as the other cows. No doubt this large quantity caused a depressing effect upon the percentage of nutrients digested.

When the results of the two trials are considered together it is plain that the dry matter and all constituents of the dry matter except phosphorus were more completely digested in the rations of grass alone than in the rations of grass and hay. The substitution of hay for a portion of the grass did not improve the apparent digestibility of the ration.

Every constituent except calcium was apparently more efficiently digested in the ration containing grass and dehydrated hay than in the one containing grass and field-cured hay. This result is not unexpected in view of the fact that the dehydrated hay was more finely divided than the field-cured hay and contained a smaller percentage of crude fiber. That there is not more difference in the digestion of the dry matter is explained by the fact that the dehydrated hay contained a large quantity of mineral matter, probably silica, which of course was not digested. Raking the crops when wet or green with a side delivery rake set low may have mixed dirt with the crop and thus increased the content of mineral matter.

In the second trial the ration of grass and hay was more efficiently digested than the ration of hay alone except as regards the ether extract.

A smaller percentage of the calcium and phosphorus was retained than was the case with the other constituents. Much of the calcium and phosphorus is ordinarily excreted in the alimentary tract. The figures given in the tables for percentage digested mean the percentage retained and represent the apparent rather than the actual digestibility. When a ration of hay alone was fed both trials showed that more calcium was excreted in the feces than was consumed in the feed. It appears that green grass contains some factor, as yet unidentified, which promotes the assimilation of calcium.

Table 9 shows the average digestion coefficients for the different constituents of the green grass fed to the two cows A-43 and A-46, for similar experiments conducted with fresh green grass by Armsby (*1, p. 623*), and by Newlander and Jones (*11-a*) and for experiments with dehydrated grass by Newlander and Jones (*11-a*) and Hodgson and Knott (*7*).

TABLE 9.—*Digestion coefficients for fresh and dehydrated pasture herbage fed cows in 3 separate experiments*

Station	Material fed	Average coefficient of digestion				
		Dry matter	Protein	Ether extract	Nitrogen-free extract	Crude fiber
		Percent	*Percent*	*Percent*	*Percent*	*Percent*
Beltsville, Md	Fresh pasture grass	71.5	77.3	60.7	76.9	76.8
State College, Pa	do		68	60	75	70
Burlington, Vt	Fresh young grass	71.0	76.5	40.0	77.9	74.4
Burlington, Vt	Dehydrated young grass	72.4	71.0	46.4	81.6	73.3
Puyallup, Wash	Dehydrated pasture mixture	67.6	74.9	21.9	74.6	72.7

In order to establish the truth or falsity of the claim that the addition of hay to a ration of grass promotes rumination, all of the cows were watched for 48 consecutive hours in each of the two digestion trials. Table 10 shows the number of minutes the cows on different feeds chewed their cuds in 24-hour periods.

TABLE 10.—*Comparison of the time consumed in remastication by cows during 24-hour periods on different roughages*

Ration	Time spent in remastication			
	First trial		Second trial	
	Total	Per kilogram of dry matter in the ration	Total	Per kilogram of dry matter in the ration
	Minutes	*Minutes*	*Minutes*	*Minutes*
Grass only	321	42	373	44
Grass and hay	338	46	367	43
Hay only	[1] 560	[1] 38	[2] 386	[2] 56

[1] Finely chopped, dehydrated hay.
[2] Long, field-cured hay.

Table 10 shows that the number of minutes spent by the cows in remasticating a ration of grass was about the same per unit of dry matter consumed as was spent in remasticating a ration of hay and grass. On the basis of dry matter consumed slightly less time was spent in remasticating the chopped hay than in remasticating the grass. The time spent in remasticating a unit of dry matter in the long hay was almost one half greater than in remasticating the finely chopped hay.

The green color of the feces from the cows in the digestion trials varied directly with the amount of green coloring matter in the ration. The feces from the cows fed grass alone were the greenest and those from the cows fed grass and hay next greenest. As grass fed alone was more efficiently digested than grass and hay, there appears to be no basis for the claim that greenness of the feces is evidence of imperfect digestion. Furthermore, in observations of cows in the general herd, cows fed a hay having much green color passed green feces, cows fed a hay lacking in green color passed blackish-colored feces; and those fed wheat straw passed yellowish feces. The color of the feces apparently depends upon the color of the feed rather than upon the efficiency of digestion.

This experiment gives some information on the quantity of grass that cows such as those used in these tests will consume. When the cows were fed grass alone they always refused a small portion, showing that they were fed at or near the limits of their appetites. In the first digestion trial cow A-46 ate on an average 65 pounds of grass per day, and in the second trial cow A-43 ate 63 pounds of grass per day. When the digestion trials were concluded both of these cows were fed all the grass they would eat for several days. Cow A-43 averaged 71 pounds per day for 4 days and cow A-46 averaged 69 pounds. On the basis of the Savage standard and using the data of these experi-

ments for determining the digestible nutrients, it is estimated that 70 pounds of grass per day will provide the nutrients required by a 1,100-pound cow for maintenance and for production of 15 pounds of milk testing 3.5 percent. In this connection it should be borne in mind that these cows were yielding only 16 to 22 pounds of milk a day. The appetites of low-producing cows are not as keen as those of high-producing cows. At Huntley, Mont., this Bureau found that cows somewhat larger than those in this experiment and giving 30 pounds of milk per day ate on an average 136.6 pounds of grass per day containing 31.8 pounds of dry matter. At Beltsville, Md., too, in an experiment to determine how much grass cows would graze, good producing Holsteins and Jerseys ate almost 100 pounds per day of grass having about the same water content as the grass fed to the two cows in this experiment.

SUMMARY OF THE RESULTS

The average coefficients of digestion of constituents in green grass fed to two cows were as follows: Dry matter, 71.5; protein, 77.3; ether extract, 60.7; nitrogen-free extract, 76.9; crude fiber, 76.8; calcium, 40.4; and phosphorus, 29.9.

The ration of green grass and field-cured soybean hay and one of green grass and dehydrated soybean hay were, on the whole, less efficiently digested than that of grass alone, but excelled soybean hay alone.

The substitution of soybean hay for a portion of the grass did not improve the coefficient of digestion of any constituent except phosphorus.

Green color of the feces is not indicative of imperfect digestion.

The feeding of hay along with grass caused little or no difference in the time spent in rumination per unit of dry matter consumed.

CONDITION OF THE COW AT CALVING TIME

Dairy farmers in general are of the opinion that it pays to have cows in very good condition or even fat at calving time. It has been demonstrated that if cows calve in a fat condition, they will produce more milk for a time after calving than they will if they calve in a thin condition. However, whether cows will produce enough more milk to pay for the extra feed required to make them fat before calving has never been determined.

A previous investigation (*14*) at Beltsville showed that liberal grain feeding for as long as 2 months before calving did not in itself lead to increased milk production after calving; also, it failed to improve the condition of the cows to any marked extent. Therefore, the theory was advanced that the state of flesh rather than the rate of feeding just before calving was the important factor in influencing the yield of milk after calving. Care was taken in the investigation reported here to have a material difference in the condition of the cows at calving time.

PLAN OF THE INVESTIGATION

The object of this experiment was to have the same cows fat and thin at alternate calvings and to compare the production and feeds eaten by the fat cows with the production and feeds eaten by the thin cows. Observations made before this investigation was begun indi-

cated that cows calving in a fat condition and cows calving in a thin condition came to much the same state of flesh within 3 months after calving. For this reason, and because these cows were being used in other investigations which did not permit careful control of feeds and methods of handling for an extended period, it was planned to use the data on production and on feeds eaten during only the 90 days after calving. Data on feed consumption during the dry period and on the feed consumption and milk production for the 30 days previous to the dry period were used along with the data on feed consumption and milk production for the 90 days after calving to determine the economy of having cows fat or thin at calving time.

While it was impracticable to control the feeding after the 90-day period with sufficient care to make entirely satisfactory comparisons for the later months of lactation, the methods of feeding and handling were much the same for both groups of cows, and a chart shows the milk production of both fat and thin cows for 270 days. Neither was it practicable to keep the cows off pasture; besides the desirability of so doing would be open to question because of the well-known beneficial effects of pasture grass upon the nutrition of dairy cows. Since the quantity of nutrients that a cow obtains from pasture cannot be determined exactly, it was estimated. Although the estimate is of doubtful accuracy, it is thought that the error in this respect is small, especially in view of the fact that both fat and thin cows were on pasture very nearly the same number of days. An attempt was made to have the dry periods of comparable length so that the influence of this factor might be eliminated.

In order to have the fat cows in the desired state of flesh at calving time, it was necessary to begin giving some of them extra feed before they went dry. On the other hand, some of the cows that were to be thin were fed less than they would ordinarily have received. The result was that the cows that were to be fat gave an average of almost 100 pounds more milk in the 30 days previous to the dry period than did the cows that were to be thin. This, of course, had to be considered in determining the relative economy of having cows fat or thin.

The feed was reduced to terms of grain for two reasons: (1) because grain has a market value that can be ascertained, and (2), because the principal difference in the feeding of cows to have them fat or thin would be in the grain. To reduce the roughages to equivalent grain values, 1 pound of grain was considered equal in feeding value to 1.43 pounds of hay or 4.29 pounds of silage. The grass eaten by cows from the beginning of the pasture season to June 1, was assumed to be equal to 25 pounds of grain per cow per day; for the month of June, 19 pounds; and for the rest of the season, 14 pounds, unless the pasture was known to be incapable of providing this quantity of feed, in which event a smaller grain equivalent was assigned.

The rations of the fresh cows were increased gradually for 3 or 4 weeks, at which time most of the cows were on full feed. Thereafter the rations of the cows were adjusted once a month approximately in accordance with accepted standards for digestible nutrients. The grain mixture fed was made up as follows: Hominy feed, 100 pounds; wheat bran, 100 pounds; ground oats, 100 pounds; cottonseed meal, 50 pounds; linseed meal, 50 pounds; and common salt, 4 pounds.

Eight grade and two registered Holstein cows were used. Each of these has completed two lactation periods, one when fat and one when

thin. In addition, five of them have calved the third time and have production records for 90 days.

Previous experience indicated that body weight after calving was not in itself an accurate measure of the cow's condition, because it was not always possible to weigh each cow immediately after calving, and because the "fill" of the animal varied greatly with different cows. The thin cows, on account of keener appetites, tended to carry more "fill." A system of rating was adopted in which 70 represented good milking condition, 95 "hog fat", and 45 emaciated. Figure 3 shows

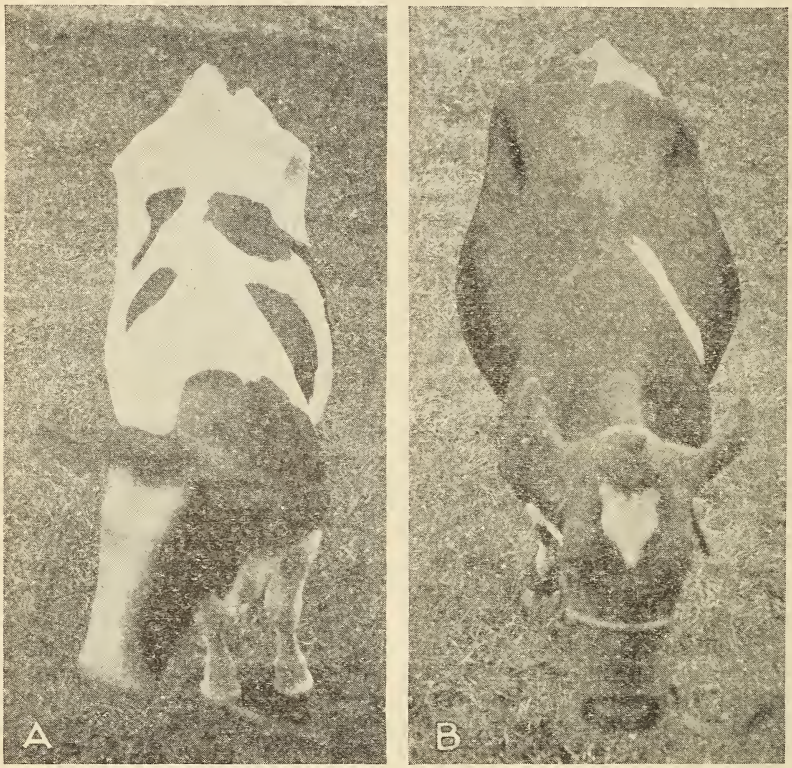

FIGURE 3.—*A*, cow rated 60, in about the same conditions as the average thin cow; *B*, cow rated 80, not quite as fat as the average fat cow in this experiment.

two cows rated at 60 and 80. The difference in the condition of these two cows is hardly as marked as that between the average thin and fat cows of this investigation. The cow rated at 60 is in about the same condition as the average cow of the thin group, but the cow rated at 80 is not quite as fat as the average cow of the fat group.

RESULTS OF THE EXPERIMENT

Table 11 shows the feed consumption and the milk and butterfat production of the 10 cows, when they calved in a fat condition and when they calved in a thin condition, for the 30 days before the dry period and the 90 days after calving, as well as the feed consumed during the dry period. When a cow had two records in fat condition or

two records in thin condition at time of calving, an average for her two records is included.

PRECALVING DATA

The two groups were dry almost the same number of days on an average. The cows when thin averaged 6 years 5 months of age at time of calving, when fat, 6 years 2 months. Although the difference in age is not sufficient to introduce a significant error the advantage is slightly with the thin cows.

The fat cows had consumed a little more feed than the thin cows during the 30 days preceding the dry period and considerably more during the dry period. They were on pasture an average of 18.5 days during the 30-day and the dry period, as against 25 days for the thin cows. After calving, however, the fat cows were on pasture 33 days as against 23.5 days for the thin cows. The fat cows averaged only 3 days more on pasture than the thin cows in the period from 30 days before drying until 90 days after calving.

FEED CONSUMPTION AND MILK AND BUTTERFAT PRODUCTION AFTER CALVING

The grain equivalent of the feed eaten during the 90 days after calving averaged 2,911 pounds for the fat cows and 2,718 pounds for the thin cows. If 0.44 pound of grain is deducted for each pound of milk produced during this period, there remains for the maintenance of the fat cows 961 pounds of grain equivalent and for the maintenance of the thin cows 980 pounds. The number of days from the time the first weight was taken after calving to the ninetieth day was 75 in the case of the fat cows and 79 in the case of the thin cows. Although the nutrients available for maintenance were nearly the same for both groups, the fat cows lost on an average of 24 pounds each in the 75 days, while the thin cows gained 16 pounds in 79 days. These results indicate that the thin cows made more efficient use of their feed than did the fat cows.

The fat cows averaged 483 pounds more milk and 16.5 pounds more butterfat than the thin cows in the first 90 days after calving. They reached the peak of their production in 41 days, while the thin cows reached the peak in 38 days. At the peak the fat cows gave 57 pounds of milk a day, the thin cows 53 pounds; and the average production from the eighty-sixth to the ninetieth day after calving showed that the fat cows were still giving about 3 pounds more a day. The milk was tested for 2 consecutive days in each half month. The average percentage of butterfat in the milk of the fat cows was 3.51 and that in the milk of the thin cows was 3.52.

TABLE 11.—*Feed consumption and milk and butterfat production for 10 cows calving in a fat condition and for the same cows calving in a thin condition*

Cow no. and condition	Rating	Time dry	Age at calving	Feed and production for 30 days previous to dry period						Feed while dry				Feed and production for 90 days after calving						Equivalent of feed in terms of grain	Days after calving to reach peak of production	Peak of milk production	Average of 5 days milk eighty-sixth to ninetieth day after calving
				Grain	Hay	Silage	Pasture	Milk	Butterfat	Grain	Hay	Silage	Pasture	Grain	Hay	Silage	Pasture	Milk	Butterfat				
		Days	*Yr.*	*Mo.*	*Lb.*	*Lb.*	*Lb.*	*Days*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Days*	*Lb.*	*Lb.*	*Lb.*	*No.*	*Lb.*	*Lb.*
A-2:																							
Fat	90	67	8	5	210	445	596	0	281	11	784	635	1,320	0	584	433	470	64	3,749	145	4,668	33	53	35
Thin	55	72	9	4	168	460	0	0	106	4	288	599	0	0	761	1,547	0	31	3,237	109	3,816	66	48	37
Fat	80	76	10	9	168	734	770	2	315	12	631	387	899	54	904	89	571	86	2,808	87	5,563	29	38	28
Average of 2 fat records	85	72	9	7	189	590	683	1	298	12	708	511	1,110	27	744	261	520	75	3,278	116	5,116	31	46	32
A-19:																								
Fat	80	67	5	9	158	411	920	0	255	10	616	749	1,340	0	939	1,245	1,248	24	4,410	155	4,815	50	55	43
Thin	60	51	6	9	120	627	0	0	57	3	216	696	0	0	947	1,411	240	19	3,586	119	3,728	29	58	42
Fat	80	41	7	10	359	318	1,087	0	174	6	487	435	1,435	0	898	441	1,164	59	4,342	143	4,819	41	60	39
Average of 2 fat records	80	54	6	10	258	364	1,004	0	214	8	502	592	1,388	0	918	843	1,206	42	4,376	149	4,817	46	58	41
A-21:																								
Thin	60	80	5	1	0	0	0	30	110	4	320	438	2,342	40	780	1,580	2,966	0	3,187	114	4,511	19	39	32
Fat	80	63	6	2	300	368	585	15	169	7	701	1,376	95	19	1,345	1,906	0	0	3,995	132	5,536	48	51	40
Thin	60	68	7	4	46	100	120	30	293	10	0	50	471	58	966	1,002	2,569	0	3,281	96	3,785	34	44	29
Average of 2 thin records	60	74	6	2	23	50	60	30	202	7	160	244	1,406	49	873	1,291	2,763	0	3,234	105	4,148	26	42	30
A-27:																								
Fat	80	46	4	9	210	426	600	0	268	11	321	491	913	0	615	223	290	73	3,725	143	4,010	28	51	32
Thin	70	81	5	9	124	522	0	0	111	5	312	708	0	0	1,124	1,057	0	48	4,673	177	4,259	48	65	45
Fat	88	83	6	8	248	316	969	0	691	28	872	898	2,270	0	1,152	801	1,711	37	4,677	179	5,762	39	58	45
Average of 2 fat records	84	64	5	8	229	371	784	0	480	20	596	694	1,592	0	884	512	1,000	55	4,201	161	4,886	34	54	38
A-32:																								
Fat	80	68	3	11	132	229	1,072	30	244	11	394	864	2,179	1	1,470	1,509	952	0	4,567	167	5,232	28	54	49
Thin	60	79	5	2	163	594	0	0	173	8	316	801	0	0	1,103	1,853	0	25	4,459	154	4,480	24	55	44
Fat	80	89	6	6	210	359	1,036	0	577	22	861	556	1,508	45	1,389	39	1,641	89	4,477	143	6,444	28	57	44
Average of 2 fat records	80	78	5	2	171	294	1,054	15	410	16	628	710	1,844	23	1,430	799	1,296	44	4,522	155	5,838	28	56	46
A-25:																								
Thin	55	58	4	7	116	0	637	30	138	5	232	514	1,852	12	879	1,373	2,928	0	3,686	138	4,169	31	45	41
Fat	80	100	6	0	247	517	0	0	139	5	926	2,160	0	0	1,116	1,272	0	36	4,550	162	5,953	58	63	47

A-26:																								
Fat	85	65	4	9	162	376	600	0	202	5	610	591	1,293	0	679	444	604	56	4,060	141	4,337	43	50	39
Thin	65	74	5	11	120	551	0	0	223	6	292	683	0	0	768	244	0	89	3,751	109	3,853	24	50	35
A-37:																								
Fat	80	23	3	10	110	257	191	16	431	16	136	0	0	21	1,582	1,490	315	23	4,327	137	4,531	43	54	53
Thin	55	47	5	0	86	351	0	16	93	4	6	143	0	19	1,328	1,350	0	23	3,395	115	3,669	57	49	46
270:																								
Fat	90	102	7	2	240	0	720	30	225	10	1,029	755	3,312	0	1,925	1,353	3,599	0	5,982	220	6,870	27	79	75
Thin	55	77	8	2	324	236	900	30	743	29	296	727	2,310	3	1,758	1,828	1,090	0	5,352	218	5,614	27	70	67
277:																								
Fat	80	45	6	3	380	306	548	13	623	26	270	348	1,360	5	1,360	1,814	3,261	0	5,034	182	5,196	49	61	55
Thin	60	61	7	2	120	176	824	30	360	13	612	720	1,772	31	1,307	1,636	1,056	0	4,119	146	5,182	45	50	48
Average: [1]																								
Fat	82.4	66.6	6	2	228.6	344.3	616.9	9.0	319.1	12.5	610.6	773.7	1,199.4	9.5	1,198.3	1,069.4	1,180.1	33.1	4,432.5	155.5	5,308.0	40.7	57.2	46.6
Thin	59.5	67.4	6	5	136.4	356.7	242.1	13.6	220.6	8.4	273.0	583.5	734.0	11.4	1,084.8	1,359.0	807.7	23.5	3,949.2	139.0	4,291.8	37.7	53.2	43.5

[1] Average of the average record per cow.

MILK-PRODUCTION CURVES

The average daily production of milk by 10-day periods starting the third day after calving for the 10 cows both when they calved in a fat condition and when they calved in a thin condition is shown in figure 4. The cows when fat started their lactation at a higher level, reached a higher peak of production and fluctuated less in milk production then when they had calved in a thin condition. During the eleventh 10-day period, however, the production curves cross and thereafter the cows calving in a thin condition produced slightly more than those calving in a fat condition. While the production curves cover 270 days, it is thought that the results after 200 days are of no particular significance because of the influence of preg-

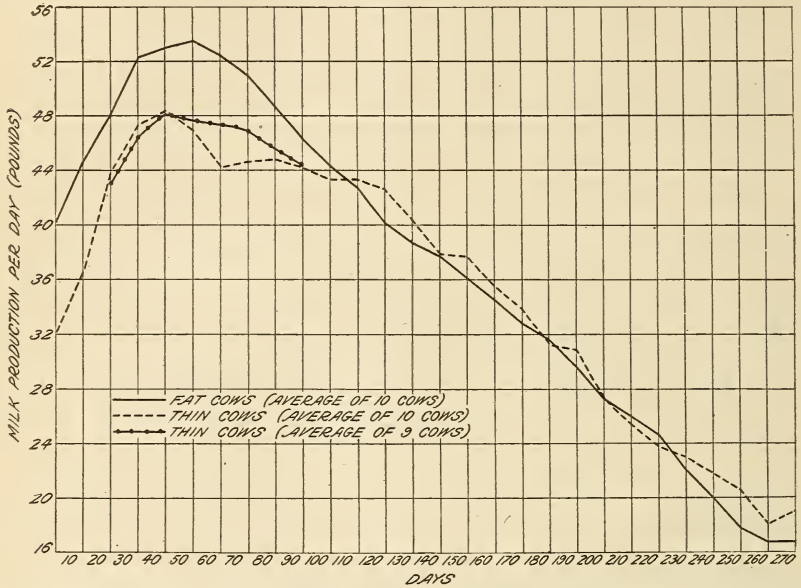

FIGURE 4.—Average daily milk production of 10 cows, both when they had calved in a fat condition and when they had calved in a thin condition.

nancy and other conditions. In fact, no attempt was made after 90 days to keep the conditions comparable for the two groups. As it happens, however, both groups were handled and fed in much the same way throughout the lactation periods. The break in the curve of the thin cows at the sixth 10-day period is due to one of the cows gorging herself with hay. In order to make this cow thin before calving her roughage allowance was much reduced and she had gotten out of the habit of eating a large quantity of hay. It is thought that the trouble would not have occurred if she had been generously fed on roughage both before and immediately after calving. The average daily milk production of the 9 cows, when this one cow is omitted, is also shown in figure 4.

RELATION OF FEED CONSUMPTION TO PRODUCTION

The figures in table 11, for the feed consumed during the 30 days previous to the dry period, during the dry period, and during the 90 days after calving, expressed in terms of grain, show that the fat cows ate a total of 10,162 pounds more than the thin cows. In the 30 days previous to the dry period and in the 90 days after calving the fat cows produced a total of 5,818 pounds more milk and 206 pounds more butterfat than the thin cows, of which 4,833 pounds of milk and 165 pounds of butterfat was produced in the 90 days after calving.

Ninety days after calving the fat cows were still 34 pounds heavier on an average than the thin cows, and 120 days after calving were only 18 pounds heavier. In both production and body weight the fat cows evidently maintained an advantage over the thin cows for a period longer than 90 days, but since the production curves (fig. 4) cross in the eleventh 10-day period and thereafter the advantage was generally with the cows of the thin group, it may be assumed for the purpose of determining the economic relationships that the two groups were equal at the end of 90 days. During the period between 90 and 200 days the fat group produced 39,540 pounds of milk and the thin group produced 40,375 pounds, or 835 pounds more than the fat cows.

Whether 10,162 pounds of grain is worth more or less than 5,818 pounds of milk testing 3.5 percent butterfat will depend upon the prices of each, which, of course, vary greatly in different parts of the United States.

Attention is called to the fact that 1 pound of grain used to fatten the cows returned less than 0.6 pound of milk, whereas 1 pound of grain converted directly into milk testing 3.5 percent butterfat should return about 2.3 pounds of milk. Evidently the conversion of feed to gain in weight to milk is not as efficient as the conversion from feed to milk direct.

INFLUENCE ON THE HEALTH ON THE COWS

Two of the cows calving in a fat condition had excessive congestion of the udder at calving time; these cows did not have any such trouble when they calved in a thin condition.

Two of the thin cows retained the placenta after calving. One of these gave birth to twin calves, which may have had something to do with the retention of the placenta.

In other respects the health of the two groups was equal so far as could be observed.

DISCUSSION OF RESULTS

Under the conditions of this experiment it appears that the fattening of cows previous to calving is of doubtful economic value. It should be borne in mind, however, in the interpretation of the data presented that all of the cows soon after calving were fed approximately according to their requirements for total digestible nutrients, whereas an examination of herdbooks from dairy herd-improvement associations shows that most high-producing cows are underfed after calving, when at the peak of their production. Possibly, when cows are underfed as stated the reserve of flesh carried by the fat cows would cause

them to show up relatively better than did the fat cows in this investigation.

Probably the most economical practice would be to have the cows in a state of flesh somewhere between the averages of the two groups presented here. For example, the roughage allowance was limited for some of the cows in this investigation that were to be thin. In practice it seems that the feeding of roughage should rarely ever be limited. If cows have been adequately fed throughout their lactation periods they should be carrying enough flesh at time of drying off so that an allowance of, say 4 pounds of grain a day, along with all the medium to good roughage they will eat will put them in satisfactory condition for calving. Probably with still better roughage the grain may be eliminated entirely during the dry period. As cows normally lose some weight after calving it seems that at calving time they should be carrying enough flesh so that they can lose this weight and still not become what would be termed thin. Probably they should be in good condition but still not very fat at time of calving.

The exact relation between the feed required to fatten a cow before calving and the additional production obtained as a result of fattening must not be considered as having been definitely settled by this investigation. Cows should be kept under controlled conditions for the entire time they are on experiment, and they should have at least two lactation periods in succession without change in the state of flesh at calving time. It would be desirable, also, to have a third group of cows, in a medium condition of flesh at calving time, to compare with the groups of thin and fat cows.

COMPARISON OF SEVERAL BEDDING MATERIALS FOR DAIRY CATTLE

An investigation was conducted to compared the efficiency and economy of peat moss, wheat straw, wood shavings, and buckwheat hulls as bedding materials for dairy cattle. The peat moss was of foreign origin, contained over 26 percent moisture, and was of the grade commonly used for bedding. The shavings were fir and western white pine. Determinations were made of the fertilizing constituents, the water-holding capacity, and the bulkiness of the various bedding materials, and also of the quantities used in actual practice. Observations were made on the cleanliness of the cows bedded with peat moss as compared with those bedded with wheat straw.

FERTILIZING CONSTITUENTS

Each of the bedding materials, with the exception of the buckwheat hulls, was analyzed for water, nitrogen, phosphorus, and potassium. The results are given in table 12.

TABLE 12.—*Water and fertilizing constituents in bedding materials* [1]

Bedding material	Water	Nitrogen	Phosphorus	Potassium
	Percent	*Percent*	*Percent*	*Percent*
Peat moss	26.3	0.67	0.030	0.009
Wheat straw	7.9	.45	.084	.611
Wood shavings	7.8	.02	.012	.011

[1] Analyses made by C. B. Parker, junior chemist.

Peat moss excelled the wheat straw and wood shavings in content of nitrogen. The wheat straw was far superior to the other two materials in both phosphorus and potassium. Wood shavings was easily the poorest of the three materials in fertilizing constituents.

WATER-HOLDING CAPACITY

The water-holding capacity of the various materials was determined by weighing out a small amount of each and placing it in a cheesecloth bag. The bag of material was soaked in water 2 hours and then weighed; it was soaked again 21 hours and reweighed. Before each weighing it was allowed to drain 30 minutes in order to get rid of the free water. After 2 hours of soaking, the peat moss had absorbed 4.7 times its weight of water, the wheat straw 2.2 times its weight, the shavings 1.2 times its weight, and the buckwheat hulls 0.8 of its weight. After 21 hours of soaking, the peat moss had absorbed 6.8 times its weight, the wheat straw 2.8 times, the shavings 1.5 times, and the buckwheat hulls 1.0 times.

BULKINESS

Bulkiness is an important property of bedding since one of the principal reasons for using bedding is to provide a comfortable place for cows to lie down. By taking an equal weight of each material and noting their comparative volumes it was possible to estimate the relative bulkiness. Straw was the most bulky and buckwheat hulls the least. The approximate figures are: straw 4, peat moss 2, shavings 2, and buckwheat hulls 1.

QUANTITIES USED BY COWS CONFINED IN STANCHIONS

In an experiment with 16 cows confined in stanchions, 4 each were bedded on peat moss, wheat straw, wood shavings, and buckwheat hulls. The experiment lasted 15 days. The average quantities used per cow per day were as follows:

	Pounds
Peat moss	7. 08
Wheat straw	3. 17
Wood shavings	8. 62
Buckwheat hulls	7. 43

Doubtless the reason for the much smaller quantity of wheat straw used was that it hung together and less was pushed into the gutter back of the cows than of the more finely divided materials.

PEAT MOSS AND WHEAT STRAW AS BEDDING IN BOX STALLS AND WAY STALLS

Two cows were bedded on peat moss and 2 on wheat straw in box stalls for 30 days; 4 cows were bedded similarly to the former group except that the bedding in the box stalls was confined to a space 4 by 7 feet, by means of 2 by 8 inch planks; also 4 cows were bedded on peat moss, and 4 on wheat straw, in Way stalls for 30 days.

The main features of the Way stall are as follows: The bottom of the feed manger is at or near the floor level; the cows are held by neck chains or straps; one or more crosspieces over the feed manger, at the height that a cow would hold her head when she is in a normal position, are intended to make her step back when she is not eating, and thus prevent the soiling of her bed; a crosspiece 4 inches high and adjustable to the length of the cow is placed behind the cow, in order

to confine the bedding and to cause the cow to move forward when she lies down.

The results of this experiment are shown in table 13.

TABLE 13.—*Relative quantities of peat moss and wheat straw used in bedding cows in box stalls and in Way stalls*

Item	Bedding material used per cow per day	
	Peat moss	Wheat straw
Box stalls:	*Pounds*	*Pounds*
Bedding spread over the entire floor	14.30	17.18
Bedding confined to a space 4 by 7 feet	10.92	13.37
Way stalls	4.63	4.55

In the box stalls 20 to 22 percent more straw than peat moss was used, but in the Way stalls there was no significant difference. Confining the bedding to a small space in the box stall made a little more difference in the quantity used than did the kind of bedding. The cows in the box stalls were not groomed at any time during the experiment. At the end of the 30 days, observations showed a slight advantage of peat moss over wheat straw in keeping the cows clean. Although confining the bedding material to a small space in the box stall required less bedding, it did not result in any greater cleanliness of the cows, because the cows would stand partly in and partly out of the bedded space.

One cow was kept for 30 days in a box stall in which the bottom of the bed was raised 5 inches above the floor, the theory being that when she started to step out of the bed she would go all the way out. This method of making a bed resulted in the use of a trifle less straw and in considerably greater cleanliness.

PEAT MOSS AND WHEAT STRAW AS BEDDING IN CALF PENS

Two experiments with bedding materials for young calves were conducted during August. As the doors from the calf pens to the adjoining yards were left open, the results shown do not represent continuous stabling of the calves. Data regarding the bedding materials used in the two experiments are presented in table 14.

TABLE 14.—*Comparison of peat moss and wheat straw as bedding in calf pens*

Group and bedding material used	Period of trial	Calves in group	Average weight of calves	Floor space per calf	Bedding material used—		Manure produced—	
					Per square foot in making bed the first day	Per calf per day	Per calf per day	Per pound of bedding
Larger calves:	*Days*	*Number*	*Pounds*	*Square feet*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Peat moss	10	9	161	25	0.30	2.5	12.0	4.8
Wheat straw	16	9	177	25	.28	2.4	12.7	5.2
Smaller calves:								
Peat moss	16	5	146	28	.60	1.4	7.5	5.5
Wheat straw	10	5	133	28	.27	1.8	9.0	5.0

Although about the same quantity of each material was used in making a bed the first day for the larger calves, it was found that twice as much peat moss as wheat straw was required at first to provide a bed of equal suitability and about the same quantity of each during the experiment. When the pens were cleaned it was observed that there was more free liquid manure present in the pens bedded with straw than in the pens bedded with peat moss. However, the results of the experiment on the whole indicate that the greatly superior water-holding capacity of the peat moss does not materially reduce the quantity of bedding actually required in practice.

Great numbers of fly larvae were found when the manure was removed from the pens. Apparently the peat moss had no inhibiting effect whatever upon the multiplication of flies.

The claim is made by dealers in peat moss that this material will keep down the odor of ammonia in the stable. No conclusive experiments were made to verify this claim, but it was noted that when cow urine was placed with peat moss in a tightly covered jar and allowed to stand several days the odor of ammonia upon the removal of the cover was much less pronounced than was the case when the urine was placed in a jar with wheat straw. Previous work also indicates the soundness of this claim, as attested by the following extract from Storer (*13, p. 331*):

> This peat-fiber absorbs a much larger amount of water than straw can, and the humic acids in it act both to hinder the fermentation of urine and to hold the ammonia which finally results from its decomposition.

SUMMARY

In total content of fertilizing constituents wheat straw, peat moss, and wood shavings ranked in the order given.

In water-holding capacity peat moss was far superior to wheat straw, wood shavings, and buckwheat hulls, the four materials ranking in the order given.

In bulkiness wheat straw was the highest, peat moss and wood shavings were about the same, and buckwheat hulls the lowest.

Cows confined in stanchions with a gutter behind used very much less wheat straw than peat moss, buckwheat hulls, or wood shavings.

A little less peat moss than wheat straw was used in bedding box stalls for cows but about the same in bedding Way stalls.

The peat moss showed a very slight advantage over wheat straw in keeping the cows clean in box stalls.

Confining the bedding to a small space in the box stalls did not result in greater cleanliness of the cows except when the bed was raised, but less bedding was required.

A little less peat moss than wheat straw was used in bedding calf pens.

Flies bred readily in both the peat-moss manure and the straw manure.

The claim that peat moss will keep down the odor of ammonia in the stable appears justified.

GROOMING DAIRY COWS BY HAND AS COMPARED WITH GROOMING BY MEANS OF A VACUUM CLEANER

An experiment was conducted to determine the relative advantages or disadvantages of grooming dairy cows by hand and grooming them by means of a vacuum-cleaning machine. Twenty-six cows on advanced-registry test at Beltsville were divided into two groups of 13 cows each. Each group comprised 7 registered Jerseys and 6 registered or grade Holsteins, and the groups were made as nearly alike as possible from the standpoint of breed, age, production, and stage of lactation.

The experiment was run for a period of 4 months—April to July 1931, inclusive. One group was groomed by hand the first 2 months and by vacuum cleaner the last 2 months. The other group was groomed by vacuum cleaner the first 2 months and by hand the last 2 months.

Two cows, one in each group, were removed from the experiment during the last 2 months. In addition, 1 cow in each group contracted mammitis, and 1 cow in the hand-groomed group had an attack of indigestion.

Tables 15 and 16 show the total production of milk and butterfat during each half of the experiment, and the decline in milk production as measured from the first 10 days to the last 10 days of each 2-month period.

TABLE 15.—*Total milk and butterfat production and the increase or decrease in milk production of hand-groomed cows and of vacuum-cleaner-groomed cows during the 2-month experimental period, April and May 1931*

HAND-GROOMED COWS

Cow no	Total production						Milk produced in first 10-day and last 10-day period		Increase (+) or decrease (−) in milk from first 10-day to last 10-day period	
	Milk			Butterfat						
	April	May	Total	April	May	Total	April 1–10	May 22–31		
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Percent*
A-50	841.4	851.8	1,693.2	30.71	29.39	60.10	288.3	278.6	−9.7	−3.4
A-53	1,375.1	1,249.5	2,624.6	44.14	44.11	88.25	462.2	382.9	−79.3	−17.2
291	1,483.6	1,435.1	2,918.7	48.66	43.91	92.57	487.5	447.6	−39.9	−8.2
602	1,480.2	1,375.6	2,855.8	71.64	60.39	132.03	507.2	433.9	−73.3	−14.5
637	880.1	934.1	1,814.2	43.74	44.46	88.20	288.4	300.8	+12.4	+4.3
693	793.7	817.3	1,611.0	44.45	46.26	90.71	261.3	256.0	−5.3	−2.0
697	661.4	678.9	1,340.3	39.35	41.96	81.31	218.9	212.1	−6.8	−3.1
698	599.1	639.7	1,238.8	35.77	39.53	75.30	198.7	197.0	−1.7	−.9
836	1,817.2	1,899.0	3,716.2	60.88	61.34	122.22	633.8	616.8	−17.0	−2.7
840	1,389.5	1,390.8	2,780.3	51.69	45.62	97.31	467.3	444.3	−23.0	−4.9
843	1,564.9	1,594.7	3,159.6	53.68	50.87	104.55	524.0	501.2	−22.8	−4.4
1004	473.8	463.5	937.3	24.45	26.47	50.92	157.0	144.9	−12.1	−7.7
1005	718.3	718.5	1,436.8	34.12	33.12	67.24	239.4	228.3	−11.1	−4.6
Total	14,078.3	14,048.5	28,126.8	583.28	567.43	1,150.71	4,734.0	4,444.4	−289.6	−6.1

TABLE 15.—*Total milk and butterfat production and the increase or decrease in milk production of hand-groomed cows and of vacuum-cleaner-groomed cows during the 2-month experimental period, April and May 1931*—Continued

VACUUM-CLEANER-GROOMED COWS

Cow no.	Total production						Milk produced in first 10-day and last 10-day period		Increase (+) or decrease (−) in milk from first 10-day to last 10-day period	
	Milk			Butterfat						
	April	May	Total	April	May	Total	April 1–10	May 22–31		
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Percent*
A-44	1, 257. 1	1, 271. 7	2, 528. 8	44. 75	43. 62	88. 37	432. 3	405. 9	−26. 4	−6. 1
A-51	1, 187. 8	1, 187. 8	2, 375. 6	39. 79	38. 01	77. 80	444. 0	386. 9	−57. 1	−12. 9
A-52	1, 071. 3	1, 106. 6	2, 177. 9	34. 60	37. 85	72. 45	386. 3	344. 9	−41. 4	−10. 7
A-55	1, 664. 0	1, 614. 1	3, 278. 1	47. 26	46. 97	94. 23	569. 4	514. 4	−55. 0	−9. 7
636	1, 089. 2	968. 9	2, 058. 1	59. 25	56. 87	116. 12	372. 1	292. 0	−80. 1	−21. 5
648	1, 465. 1	1, 456. 7	2, 921. 8	57. 29	65. 41	122. 70	487. 0	389. 7	−97. 3	−20. 0
696	930. 5	998. 6	1, 929. 1	41. 31	43. 34	84. 65	300. 1	319. 6	+19. 5	+6. 5
699	737. 2	716. 6	1, 453. 8	41. 43	40. 42	81. 85	242. 1	236. 1	−6. 0	−2. 5
839	940. 6	943. 7	1, 884. 3	40. 82	37. 75	78. 57	288. 3	296. 2	+7. 9	+2. 7
841	1, 052. 8	1, 002. 4	2, 055. 2	35. 69	36. 59	72. 28	352. 4	310. 1	−42. 3	−12. 0
1001	638. 1	658. 5	1, 296. 6	40. 71	42. 08	82. 79	205. 1	213. 6	+8. 5	+4. 1
1002	515. 3	533. 6	1, 048. 9	31. 18	31. 59	62. 77	168. 3	169. 4	+1. 1	+. 7
1010	517. 4	531. 6	1, 049. 0	29. 54	28. 76	58. 30	173. 5	170. 1	−3. 4	−2. 0
Total	13, 066. 4	12, 990. 8	26, 057. 2	543. 62	549. 26	1, 092. 88	4, 420. 9	4, 048. 9	−372. 0	−8. 4

TABLE 16.—*Total milk and butterfat production, and the increase or decrease in milk production, of hand-groomed cows and of vacuum-cleaner-groomed cows during the 2-month experimental period, June and July 1931*

HAND-GROOMED COWS

Cow no.	Total production						Milk produced in first 10-day and last 10-day period		(Increase (+) or decrease (−) in milk from first 10-day to last 10-day period	
	Milk			Butterfat						
	June	July	Total	June	July	Total	June 1–10	July 22–31		
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Percent*
A-44	1, 158. 5	1, 103. 8	2, 262. 3	40. 20	38. 52	78. 72	384. 4	345. 2	−39. 2	−10. 2
A-51	1, 122. 9	931. 8	2, 054. 7	40. 87	31. 59	72. 46	381. 4	267. 2	−114. 2	−29. 9
A-52	1, 040. 3	966. 4	2, 006. 7	42. 24	33. 92	76. 16	343. 6	293. 5	−50. 1	−14. 6
A-55	1, 468. 2	1, 207. 0	2, 675. 2	43. 31	32. 11	75. 42	494. 3	[1] 328. 8	−165. 5	−33. 5
648	1, 330. 2	1, 099. 5	2, 429. 7	61. 84	47. 30	109. 14	465. 6	342. 9	−122. 7	−26. 4
696	937. 5	808. 1	1, 745. 6	42. 02	38. 16	80. 18	315. 3	264. 2	−51. 1	−16. 2
699	521. 4	303. 3	824. 7	30. 27	16. 84	47. 11	232. 8	[2] 94. 5	−138. 3	−59. 4
839	864. 3	806. 6	1, 670. 9	34. 40	32. 05	66. 45	286. 8	254. 9	−31. 9	−11. 1
841	782. 6	868. 5	1, 651. 1	26. 69	30. 61	57. 30	265. 2	271. 6	+6. 4	+2. 4
1001	386. 0	408. 0	794. 0	42. 85	24. 50	67. 35	189. 1	139. 6	−49. 5	−26. 2
1002	429. 4	338. 3	767. 7	30. 67	20. 08	50. 75	150. 0	105. 8	−44. 2	−29. 5
1010	489. 7	306. 7	796. 4	27. 68	15. 20	42. 88	168. 2	92. 7	−75. 5	−44. 9
Total	10, 531. 0	9, 148. 0	19, 679. 0	463. 04	360. 88	823. 92	3, 676. 7	2, 800. 9	−875. 8	[3]−23. 8

VACUUM-CLEANER-GROOMED COWS

A-50	813. 1	750. 8	1, 563. 9	28. 05	26. 43	54. 48	274. 9	213. 1	−61. 8	−22. 5
A-53	1, 215. 4	1, 080. 8	2, 296. 2	42. 17	38. 58	80. 75	388. 1	321. 1	−67. 0	−17. 3
291	1, 230. 5	1, 090. 2	2, 320. 7	36. 67	33. 47	70. 14	427. 8	352. 3	−75. 5	−17. 6
637	842. 3	832. 1	1, 674. 4	41. 51	42. 44	83. 95	292. 3	264. 6	−27. 7	−9. 5
693	759. 1	747. 6	1, 506. 7	41. 06	42. 15	83. 21	263. 2	235. 4	−27. 8	−10. 6
697	630. 4	636. 5	1, 266. 9	39. 31	37. 57	76. 88	217. 9	186. 6	−31. 3	−14. 4
698	585. 1	581. 7	1, 166. 8	35. 45	29. 08	64. 53	203. 0	181. 9	−21. 1	−10. 4
836	1, 625. 0	1, 572. 4	3, 197. 4	54. 11	50. 63	104. 74	602. 3	467. 9	−134. 4	−22. 3
840	1, 220. 9	1, 199. 8	2, 420. 7	42. 61	40. 38	82. 99	424. 5	386. 6	−37. 9	−8. 9
843	1, 431. 6	612. 1	2, 043. 7	54. 54	26. 23	80. 77	509. 4	[1] 186. 6	−322. 8	63. 4
1004	453. 1	487. 6	940. 7	27. 45	24. 92	52. 37	153. 9	155. 5	+1. 6	+1. 0
1005	677. 4	623. 3	1, 300. 7	30. 26	32. 24	62. 50	229. 6	182. 7	−46. 9	−20. 4
Total	11, 483. 9	10, 214. 9	21, 698. 8	473. 19	424. 12	897. 31	3, 986. 9	3, 134. 3	852. 6	[4]21. 4

[1] This cow had mammitis.
[2] This cow had indigestion.
[3] Omitting A-55 and 699 the average decline is 19.4 percent.
[4] Omitting 843 the average decline is 15.2 percent.

For the first half of the experiment the group that was groomed by hand maintained production slightly better than did the group groomed by vacuum cleaner. In the second half of the experiment, however, the reverse was the case, and the difference in favor of vacuum-cleaner grooming for the second half of the experiment was about the same as the difference in favor of hand grooming for the first half of the experiment. If the records of the three cows known to have mammitis and indigestion are omitted, the difference in favor of vacuum-cleaner grooming is slightly augmented. Furthermore, by comparing the yields of milk during the 10 days before and the 10 days after the respective methods of grooming were used, it is found that a change from vacuum cleaner to hand grooming resulted in a decline of 2.1 percent, while the change from hand to vacuum-cleaner grooming resulted in a decline of only 0.6 percent.

The differences indicated may be small enough to be within the experimental error, but judging from the immediate reaction of the cows to the change in the method of grooming, it appears that, if there is an actual difference, it is in favor of the vacuum-cleaner grooming.

There was no noticeable difference in the cleanliness of the cows in the two groups. It was found, however, that the vacuum cleaner would not remove wet material from the cow and that it was not effective along the backbone, tail, or any other place that did not afford a fairly flat surface 4 inches or more in width. The vacuum cleaner appeared to be effective in removing loose hair and dust or other loose dirt from all flat surfaces.

The time required to groom the cows was recorded for a 10-day period, after the operator had become accustomed to using the vacuum cleaner. Grooming 13 cows by hand required from 30 to 39 minutes, or 2.3 to 3 minutes per cow; grooming with the vacuum cleaner required from 48 to 60 minutes, or 3.7 to 4.6 minutes per cow. On the basis of the average time spent in grooming the cows, a man could groom 22 cows an hour by hand or 14 cows an hour with the vacuum cleaner. As these cows were kept in box stalls, more time was spent in going from one cow to another and in moving the vacuum cleaner than if the cows had been stabled in stanchions; also, the difference between the time required for vacuum-cleaner grooming and for hand grooming probably would have been a little less for cows in stanchions.

PASTURE EXPERIMENT

For several years a pasture experiment has been carried on at Beltsville by the Bureau of Dairy Industry in cooperation with the Bureau of Plant Industry,[3] to compare rotation grazing with continuous grazing, fertilized with unfertilized pastures, and Reed canary grass with a pasture mixture of grasses and clovers. The general layout of the experimental pastures and the methods of grazing them are illustrated in figure 5.

The 12-acre field, divided into 6 pastures for rotation grazing, was seeded in the fall of 1928 and reseeded in the spring of 1929 with the pasture mixture. The 3 fields of about 4 acres each, used for continuous grazing, were all seeded in the spring of 1929, 2 with the pasture

[3] The agronomic phases of this work were directed by H. N. Vinall, senior agronomist, and Mason Hein, assistant agronomist, Bureau of Plant Industry.

mixture and 1 with Reed canary grass. The rotation pastures and one of the continuously grazed pastures seeded to the pasture mixture were fertilized yearly by the method described later. The rotation system used was as follows: Each of the pastures in turn was grazed with milking cows for about 4 days, followed by young stock for the same number of days, the cows being moved on to the next pasture. In this way only 2 of the 6 pastures were being grazed at the same time. An attempt was made to graze all the pastures equally close by taking animals off or putting additional animals on the pastures; and to balance the different groups in breed, age, weight, condition of flesh, stage of lactation, and production of milk. In addition to pasture, hay and grain were fed to the cows in the amounts believed necessary to maintain production and body weight, and to young stock in the amounts required to support normal gains in weight.

The grazing data for the season of 1929 were not used because the rotation pastures seeded in the fall made a more vigorous early

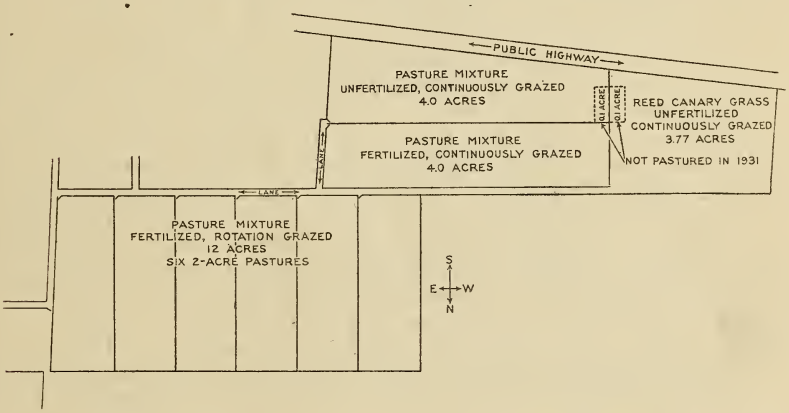

FIGURE 5.—Lay-out of the experimental pastures at the United States Dairy Experiment Station, Beltsville, Md.

growth than the continuously grazed pastures seeded in the spring. The results for the season of 1930 have been given in a previous publication (*14, p. 18–24*) together with a more detailed description of the plan of the experiment.

RESULTS FOR THE SEASON OF 1931

The season of 1931 was on the whole a very favorable one for growth of pasture plants at Beltsville, Md. Although the grass was somewhat slower in starting growth than in the spring of 1930, probably on account of the low precipitation in April 1931 and the drought of 1930, the grazing in the latter part of the season was much better than it usually is at that time of year, because of favorable rains during the period May to August. As the pasture of Reed canary grass, however, had a very unsatisfactory stand, the data on that pasture are omitted, although it was grazed throughout the season. The precipitation in 1931 from March to October, inclusive, and the average precipitation for 45 years are shown in table 17.

TABLE 17.—*Precipitation in inches by months at or near Beltsville, Md., during the growing seasons of 1931 and 1932, and the 45-year average precipitation*

	March	April	May	June	July	August	September	October
45-year average [1]	3.46	3.59	3.74	3.96	4.11	3.93	3.22	2.64
1931 [2]	3.84	2.20	3.87	4.75	4.58	7.96	1.22	1.16
1932 [2]	5.59	2.45	4.94	3.72	2.70	1.53	3.67	6.38

[1] College Park, Md., record.
[2] Beltsville, Md., records.

The basis on which the yields of the different pastures are compared is the digestible nutrients produced, as calculated from the milk yield and the estimated feeding requirements of the animals on each of the pastures. When the results in 1930 were reported (*14*) there was no experimental evidence available showing the digestible nutrients required by dairy cattle in making gains in weight. Since then Eckles and Gullickson (*4*) have published results of their work on nutrients required for normal gains of young cattle, which check very well with the figures that were used in the 1930 report, although these investigators found that the maintenance requirements of young stock were greater and the growth requirements were less than had been estimated in the 1930 report. In this experiment, since the data for maintenance and for gains or losses in weight of the cows were included with those of the heifers grazing the same pastures, and since no reliable basic figures are available for calculating accurately the nutrients required for gains in weight of milk cows, it was thought best to make no change from the method used in the 1930 report. In this method 7.925 pounds of digestible nutrients per day per 1,000 pounds of live weight is allowed for maintenance and 3 pounds of digestible nutrients for each pound of gain in weight.

The average number of acres required to pasture 1 milking cow and 1 heifer during the season of 1931 on the different pastures, except the one seeded to Reed canary grass, based on a grazing period of 164 days, was as follows:

	Acres
Fertilized, rotation-grazed pastures	1.37
Fertilized, continuously grazed pasture	1.53
Unfertilized, continuously grazed pasture	2.14

Table 18 gives a record on a per acre basis of the days of grazing, production of milk and butterfat, gains and losses in live weight, supplemental feed, and nutrients for the different pastures by months for the grazing season of 1931. The digestible nutrients required by the cattle for milk production were estimated from the Savage standard and the nutrients for maintenance and for gains in weight by the method previously given. From the total requirements is deducted the number of pounds of nutrients in the supplemental feed, giving the nutrients provided by grazing, and to this amount is added the number of pounds of nutrients contained in the hay clipped from the pastures to obtain the total nutrients credited to the pastures.

The fertilized, rotation-grazed pastures yielded 23 percent more nutrients than the fertilized, continuously grazed pasture, which, however, yielded 27 percent more nutrients than the unfertilized, continuously grazed pasture.

SUPPLEMENTAL FEED

In estimating the quantities of supplemental feed that were to be given to the cows during May it was assumed that the pastures would provide enough nutrients for maintenance and the production of about 1 pound of butterfat per cow per day. Holstein cows yielding 30 pounds or less of milk a day and Jersey cows giving 20 pounds or less were not given any supplemental feed in May. For all production in excess of these quantities, supplemental feed was given in quantities specified by accepted standards; it consisted chiefly of grain, although some cows got a little hay.

Pasture and 5 pounds of hay per cow per day were expected to provide for maintenance and for the production of 24 pounds of Holstein milk or 18 pounds of Jersey milk a day in June; for maintenance and 18 pounds of Holstein milk in July, the Jerseys having been taken off pasture; for maintenance and 10 pounds of milk early in August and 20 pounds later after rains had freshened the grass; for maintenance and 25 pounds of milk in September. Grain was fed to provide for all production above the quantities stated. During August, September, and the first part of October, the cows gained back most of the loss in weight sustained in the first part of the season. The young stock were not given hay. The hay fed to the cows was mostly alfalfa, and some soybean hay.

The average rate of feeding grain for the whole season varied with the different pastures from 1 pound of grain for about 4½ pounds of milk to 1 pound for about 5½ pounds of milk, and from less than 5 to more than 6 pounds of grain for each pound of butterfat produced. The grain mixture fed consisted of 100 pounds each of hominy feed, wheat bran, and ground oats, and 50 pounds each of linseed meal and cottonseed meal. In addition to the grain mixture many of the heifers received either sprouted oats or cottonseed meal. Of the total digestible nutrients required by the cows for maintenance, milk, and gain in weight, and by the heifers for maintenance and gain in weight on the different pastures, the percentages provided by the grain and hay were as follows:

	Percent
Fertilized, rotation-grazed pastures	33
Fertilized, continuously grazed pasture	31
Unfertilized, continuously grazed pasture	29

DECLINE IN MILK PRODUCTION

Six cows were on pasture continuously for 160 days. All of these had freshened in February or March. While the number of cows is too small for comparison of the different pastures in maintaining milk production, it is interesting to note that the production of these six cows declined from a daily average of 51 pounds for the first 10-day period to 23 pounds for the last 10-day period of the grazing season. This decline, amounting to 55 percent in 5 months, is much greater than would be expected under winter conditions, though it may be typical of what usually happens under the summer conditions prevailing at Beltsville when cows must obtain most of their subsistence from pasture.

TABLE 18.—*Record of grazing and digestible nutrients per acre from different pastures and grain fed, production, and gains or losses in weight of cows and heifers during the grazing season of 1931*

FERTILIZED, ROTATION-GRAZED PASTURES

Period	Grazing			Production per acre		Gain or loss in live weight per acre		Supplemental feed per acre			Estimated digestible nutrients per acre				Nutrients in supplemental feed per acre	Nutrients credited to pasture per acre
								Grain fed								
	Calendar days	Cow-days per acre	Heifer-days per acre	Milk	Butterfat	Cows	Heifers	Cows	Heifers	Hay fed to cows	Required for maintenance	Required for milk production	Added (+) or deducted (−) for gain or loss in weight	Total		
	Number	*Number*	*Number*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Apr. 28–May 31	34	35.0	33.9	1,453.2	55.0	−16.7	+22.2	327.3	166.6	3.7	547	491	+16	1,054	362	692
June 1–30	30	20.8	20.8	733.8	26.0	+.3	+16.6	155.4	98.7	77.8	341	236	+51	628	226	402
July 1–31	31	15.5	15.5	451.1	15.46	−15.9	+2.9	97.8	74.0	62.7	249	143	−39	353	158	195
Aug. 1–31	31	16.3	16.3	475.6	15.99	+21.3	+20.7	97.5	71.5	60.4	262	147	+126	535	155	380
Sept. 1–30	30	25.1	25.1	734.8	25.62	−13.9	+28.4	142.7	72.6	62.9	393	234	+44	671	190	481
Oct. 1–11	11	7.3	7.3	232.6	7.46	+27.3	+7.2	75.9	20.5	26.3	118	70	+104	292	84	208
Total	167	120.0	118.9	4,081.1	145.53	+2.4	+98.0	896.6	503.9	[1] 293.8	1,910	1,321	+302	3,533	1,175	[2] 2,567

FERTILIZED, CONTINUOUSLY GRAZED PASTURES

Apr. 28–May 31	34	32.5	31.1	939.2	40.03	−32.2	+36.0	163.5	123.2	7.5	505	343	+11	859	213	646
June 1–30	30	22.2	22.2	700.2	23.61	−25.0	+21.7	160.0	104.8	89.7	352	216	−10	558	240	318
July 1–31	31	15.5	15.5	378.8	12.68	−17.2	+9.0	87.2	83.1	77.2	241	117	−25	333	164	169
Aug. 1–31	31	15.5	15.5	376.4	13.22	+18.2	+22.5	67.2	62.4	70.6	239	120	+122	481	131	350
Sept. 1–30	30	21.2	21.2	406.1	16.29	+11.7	+23.7	49.4	64.5	73.4	331	142	+107	580	121	459
Oct. 1–11	11	1.0	1.0	18.1	.63	0	0	6.0	4.6	4.1	[3] 16	[3] 6	[3] 0	[3] 22	[3] 10	[3] 12
Total	167	107.9	106.5	2,818.8	106.46	−44.5	+112.9	533.3	442.6	[4] 322.5	1,684	944	+205	2,833	879	[2] 2,083

Apr. 28–May 31	34	21.5	20.8	698.4	28.11	+1.3	+15.9	94.4	69.2	7.7	327	244	+52	623	123	500
June 1–30	30	15.1	15.1	475.7	17.59	−12.1	+17.2	82.0	49.1	62.0	239	158	+15	412	128	284
July 1–31	31	8.7	8.7	334.4	12.28	−15.9	+11.3	83.3	36.0	43.3	131	110	−14	227	110	117
Aug. 1–31	31	15.9	15.9	474.4	17.58	+11.3	+9.2	106.2	51.9	72.3	240	157	+62	459	153	306
Sept. 1–30	30	13.6	13.6	285.2	10.77	+1.3	+16.4	44.1	40.4	46.4	209	96	+53	358	85	273
Oct. 1–11	11	2.1	2.1	41.0	1.63	0	0	12.3	6.7	7.4	[3] 31	[3] 14	[3] 0	[3] 45	[3] 18	[3] 27
Total	167	76.9	76.2	2,309.1	87.96	−14.1	+70.0	422.3	253.3	[5] 239.1	1,177	779	+168	2,124	617	[2] 1,634

[1] Includes 39.2 pounds of soybean hay.
[2] Includes nutrients in hay clipped from pasture.
[3] Oct. 1–4.
[4] Includes 54.6 pounds of soybean hay.
[5] Includes 42.6 pounds of soybean hay.

CLIPPING THE PASTURES

The aim was to keep all the pastures grazed to the desired height at all times by increasing or reducing the numbers of animals on the pastures. This plan succeeded very well except when the Kentucky bluegrass in the pasture was going to seed. Its seed stalks shot up so rapidly that even heavy grazing would not keep them down; also, the cattle avoided the patches where the grass had headed and grazed the short grass instead. In order to get rid of the taller grass and thus induce more uniform grazing, the pastures were clipped to a height of about 4 inches. The clippings were made into hay and weighed, and from the weights and the moisture determinations the quantity of air-dry hay was estimated. The hay was assumed to contain 50 percent of digestible nutrients.

The air-dry hay removed per acre from the different pastures was as follows:

	Pounds
Fertilized, rotation-grazed pastures	419
Fertilized, continuously grazed pasture	258
Unfertilized, continuously grazed pasture	254

ROTATION GRAZING AS COMPARED WITH CONTINUOUS GRAZING

The 12-acre rotation-grazed pasture and one of the 4-acre continuously grazed pastures were similar in other respects, being seeded to the pasture mixture and regularly fertilized. The rotation-grazed pastures were credited with the production of 2,567 pounds of digestible nutrients per acre (table 18), and the continuously grazed pasture was credited with 2,083 pounds per acre. The difference of 484 pounds of nutrients would be equivalent to the nutrients in 938 pounds of alfalfa hay. If the cost of raising or of buying alfalfa hay is known, the money values of the increase due to rotation grazing can be readily estimated. Apparently if such an increase should be maintained over a number of years, it would more than repay the cost of dividing a pasture into several smaller pastures for rotation grazing. In the case of the fertilized pastures, the increase in yield of nutrients obtained by rotation grazing was 23 percent. If this same percentage of increase were to be applied to poor pasture, the advantage of rotation grazing would be less, as the cost of the additional fencing required for rotation grazing may approach or even exceed the value of the increased nutrients secured from a poor pasture as a result of rotation grazing. Rotation grazing is therefore likely to be more advantageous on good than on poor pastures.

CLUMPINESS OF THE PASTURES

One of the advantages claimed for rotation grazing is that the grass is eaten down to a more uniform height. The grass on about half or more than half of the continuously grazed pasture was more uniform in height than the grass on any of the rotation-grazed pastures. The other half of the continuously grazed pasture was almost as uniformly grazed as any of the rotation-grazed pastures. Figures 6 and 7, showing photographs taken in September 1931, are intended to show the uniformity of grazing in the two pastures.

FERTILIZATION

Fertilizer was applied to one of two 4-acre pastures which otherwise had the same treatment, both being seeded to the pasture mixture and grazed continuously; also to the rotation-grazed pasture. Four hundred pounds of superphosphate (16 percent), 100 pounds of muriate of potash (50 percent), and either 400 pounds of nitrate of soda (15 percent) or 300 pounds of sulphate of ammonia (20 percent) were applied per acre each year.

The superphosphate and muriate of potash were applied in late winter or in early spring a month or more before the cattle were turned on the pastures. One fourth of the nitrogen fertilizer was applied

FIGURE 6.—Continuously grazed pasture, in foreground, showing uniformity of grazing.

at the same time as the superphosphate and potash and the remainder in three equal applications at intervals up to midsummer. The cost of the fertilizer was $12.19 per acre. The labor of applying the fertilizer was 7½ man-hours and 1½ horse-hours per acre.

The difference between the digestible nutrients credited to the 2 fertilized and unfertilized pastures that were similarly seeded and grazed was 449 pounds per acre. This quantity of nutrients would be contained in 870 pounds of alfalfa hay. If alfalfa hay could have been purchased or raised for $28 a ton, it is estimated that the money spent for fertilizer might just as well have been spent for hay. If alfalfa

cost more than $28 per ton the advantage would be with fertilizer at $12 per acre, but if hay was less than $28 it would be cheaper than fertilizer.

It is not the intent of the writers to depreciate the value of fertilization, for it is well-known that a fertile soil is, as a rule, a prerequisite to profitable farming. However, the wisdom of applying large quantities of high-priced nitrogenous fertilizers which have only a short-time effect and that only in the presence of considerable moisture may well be questioned. At present it appears that whatever fertilizing practice is the most profitable in growing general farm crops is likely to be the most profitable in growing pasture plants.

FIGURE 7.—Rotation-grazed pasture, showing uniformity of grazing.

THE GROWTH OF WEEDS

Weeds were not a serious problem in any of the pastures. The fertilized pastures and the canary grass pasture were almost entirely free from weeds. However, in one end of the unfertilized pasture seeded to the grass mixture there was a considerable growth of ragweed and cockleburs.

RESULTS FOR THE SEASON OF 1932

The first half of the 1932 season was in general favorable to the growth of pasture plants at Beltsville, but in the second half the growth during July and August was quite slow. The record of pre-

cipitation (table 17) in 1932 shows that the precipitation in July and especially in August was unusually low as compared with the 45-year averages shown for these 2 months. The cattle were turned on the fertilized pastures April 16, 12 days earlier than in the season of 1931, and were taken off October 18, 7 days later than in 1931, a period of 186 days on the calendar. The first 6 days the cattle were pastured only in the daytime. Therefore, the pasture season was equivalent to 183 days on a 24-hour basis.

Since the stand of Reed canary grass in 1931 was rather poor and failed to improve materially with pasturing, cattle were not put on this pasture in 1932. The canary grass was cut in July, after it had formed seeds, and yielded 2,048 pounds of field-cured hay to the acre. Though the stand seemed to have improved a little, it was still unsatisfactory.

The average number of acres required to pasture 1 milking cow and 1 heifer for the season of 183 days on each of the other pastures was as follows:

	Pounds
Fertilized, rotation-grazed pastures	1. 45
Fertilized, continuously grazed pasture	1. 73
Unfertilized, continuously grazed pasture	2. 50

While these figures show the relative carrying capacity of the different pastures they do not mean that the number of acres stated would keep 1 cow and 1 heifer continuously on this pasture throughout the season. As a matter of fact, the number of animals on the pastures varied greatly during the season, depending on the rate of growth of the grass. For example, the rotation-grazed pastures had 17 cows and 17 heifers on them during most of May, and only 3 cows and 3 heifers on them during August.

Although in the previous years some of the grass formed seed heads in May and was clipped and made into hay, in 1932 the grass was kept grazed so closely so that none required clipping.

Table 19 shows a record, on a per acre basis, of the grazing, grain fed, production of milk and butterfat, and gains and losses in live weight, and nutrients for the three pastures during the grazing season of 1932.

TABLE 19.—*Record of grazing and digestible nutrients per acre from different pastures and grain fed, production, and gains or losses in weight of cows and heifers during the grazing season of 1932*

FERTILIZED, ROTATION-GRAZED PASTURES

Period	Grazing			Production per acre		Gain or loss in live weight per acre		Grain fed		Estimated digestible nutrients per acre				Nutrients in grain per acre	Nutrients credited to pasture per acre
	Calendar days	Cow-days per acre	Heifer-days per acre	Milk	Butterfat	Cows	Heifers	Cows	Heifers	Required for maintenance	Required for milk production	Added (+) or deducted (−) for gain or loss in weight	Total		
	Number	*Number*	*Number*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Apr. 16-30	[1] 12	13.7	12.7	387.4	14.02	−35.6	−0.8	62.3	29.3	210	126	−109	227	68	159
May 1-31	31	40.4	40.5	921.5	32.34	+41.2	+45.3	123.3	73.6	652	294	+259	1,205	145	1,060
June 1-30	30	27.5	27.5	720.8	23.93	−18.2	−2.0	177.5	58.0	423	221	−60	584	172	412
July 1-31	31	17.6	17.6	443.8	15.31	+15.0	+23.4	100.8	51.7	268	140	+115	523	112	411
Aug. 1-31	31	9.8	9.8	239.2	8.54	−1.5	+8.1	71.1	30.3	158	77	+20	255	75	180
Sept. 1-30	30	8.5	8.5	237.9	8.18	−4.0	+9.1	65.4	30.3	150	75	+15	240	70	170
Oct. 1-18	18	9.0	9.0	243.6	7.80	+1.5	+4.6	57.1	36.5	153	73	+18	244	69	175
Total	183	126.5	125.6	3,194.2	110.12	−1.6	+87.7	657.5	309.7	2,014	1,006	+258	3,278	711	2,567

FERTILIZED, CONTINUOUSLY GRAZED PASTURE

Apr. 16-30	[1] 12	12.0	11.0	356.2	14.53	−54.0	+9.0	72.5	28.9	179	127	−135	171	75	96
May 1-31	31	35.0	35.0	956.9	36.46	+27.7	+38.0	167.5	67.7	532	323	+197	1,052	172	880
June 1-30	30	18.7	18.7	498.0	18.72	−19.5	+13.5	127.5	49.5	297	166	−18	445	129	316
July 1-31	31	15.5	15.5	376.5	12.99	−2.8	+23.3	84.0	48.6	254	126	+62	442	96	346
Aug. 1-31	31	8.0	8.0	231.0	8.69	−2.2	+6.2	70.0	31.5	133	77	+12	222	74	148
Sept. 1-30	30	8.5	8.5	239.4	9.24	+3.0	+9.5	68.4	32.2	144	82	+37	263	74	189
Oct. 1-18	18	9.0	9.0	239.5	8.05	−5.2	+12.5	53.7	14.8	151	74	+22	247	51	196
Total	183	106.7	105.7	2,897.5	108.68	−53.0	+112.0	643.6	273.2	1,690	975	+177	2,842	671	2,171

Apr. 26–30	5	2.5	2.5	71.4	2.69	0	0	2.5	3.1	35	24	0	59	4	55
May 1–31	31	25.2	24.6	620.8	25.70	+14.5	+37.8	84.8	44.4	353	223	+157	733	96	637
June 1–30	30	15.0	15.0	328.8	11.94	−23.8	+1.2	97.5	1.3	205	108	−68	245	72	173
July 1–31	31	11.0	11.0	197.9	7.50	+3.5	+16.2	39.5	9.5	145	66	+59	270	36	234
Aug. 1–31	31	7.8	7.8	158.3	5.03	+10.5	+7.5	35.2	.4	105	47	+46	198	26	172
Sept. 1–30	30	7.5	7.5	228.1	7.09	−6.7	+7.5	73.0	3.8	115	67	+2	184	56	128
Oct. 1–18	18	4.5	4.5	126.2	4.04	−1.0	−1.7	27.0	14.3	71	38	−8	101	30	71
Total	176	73.5	72.9	1,731.5	63.99	−3.0	+68.5	359.5	76.8	1,029	573	+188	1,790	320	1,470

[1] Includes 6 days of 12-hour grazing.

SUPPLEMENTAL FEED

The quantities of supplemental feed that were to be given the cows and heifers throughout the season were estimated in the same way as in 1931. In 1932 no hay was given to the cows on pasture for two reasons. One was that a digestion experiment (p. 18) had indicated that the addition of hay to a ration of grass did not improve the ration; the other was that nutrients were provided more cheaply in grain than in hay under the conditions at Beltsville. The average rates of feeding grain to the cows on the different pastures ranged from 1 pound of grain for each 4.5 pounds of milk to 1 pound for each 4.9 pounds of milk; or from 5.6 to 6.0 pounds of grain for each pound of butterfat produced. The grain mixture fed was similar to the mixture that was fed the previous season.

For the animals grazed on the different pastures, the supplemental feed provided the following percentages of the total digestible nutrients required by the cows for maintenance, milk, and gain in weight, and by the heifers for maintenance and gain in weight:

	Percent
Fertilized, rotation-grazed pastures	22
Fertilized, continuously grazed pasture	24
Unfertilized, continuously grazed pasture	18

The amount of supplemental feed given in 1932 was less than in 1931, mainly because the cows produced a little less milk and because the heifers did not eat nearly as much grain as in 1931.

The average daily milk production of the cows in 1931 on all the pastures was 30 pounds; in 1932, 26 pounds. In 1931 the heifers ate an average of 4 pounds of grain a day; in 1932 they ate only 2.2 pounds.

COMPARISON OF ROTATION WITH CONTINUOUS GRAZING

The yield of the fertilized, rotation-grazed pastures exceeded that of the fertilized, continuously grazed pasture by 18 percent, as compared with a 23 percent increase in 1931; and exceeded that of the unfertilized, continuously grazed pasture by 48 percent as compared with an increase of 27 percent in 1931. The rotation-grazed pastures yielded exactly the same quantity as in 1931, the fertilized, continuously grazed pasture a little more, and the unfertilized continuously grazed pasture a little less.

A comparison of the 2 pastures that were treated alike, except in method of grazing, shows that the rotation-grazed, fertilized pastures were credited with 2,567 pounds of digestible nutrients per acre in both years, and the continuously grazed, fertilized pasture was credited with 2,171 pounds per acre in 1932, as against 2,083 pounds the year before. Therefore, the increase due to rotation grazing alone in 1932 was 396 pounds of digestible nutrients per acre, or a little less than in 1931. Expressed in terms of hay, 767 pounds of average alfalfa hay would provide 396 pounds of digestible nutrients.

Although the rotation-grazed pastures have consistently yielded more nutrients than the continuously grazed pastures during the 3 years of this experiment, these results must not be considered conclusive evidence of the superiority of rotational grazing. In laying out the experimental fields due consideration was given to their productiveness with the object of having them all equal in this respect.

The question has arisen, however, whether the field used for rotation grazing might not be a little better than the fields used for continuous grazing in regard to the lay of the land and the character of the soil. For this reason, it is planned to reverse the system of grazing—that is, to graze the rotation pastures continuously and the continuously grazed pastures in rotation. By so doing it is hoped to determine conclusively whether any increase in yield of pastures may be expected by grazing in rotation in this climate, under the conditions of this investigation.

WEEDS

All of the pastures were remarkably free from weeds in 1932. While the unfertilized pasture had a considerable growth of weeds in one end in 1931, it had practically none in 1932. Observations on closeness of grazing in 1932 corroborate those of the previous year, that the grass of the continuously grazed pasture was grazed down as uniformly as that of the rotation-grazed pasture.

FERTILIZATION

On the fertilized pastures, the method of applying the fertilizers and the kinds and quantities used per acre were the same as in 1931. The cost, however, was $9.75 per acre as against $12.19 in 1931. Comparison of the results for the fertilized, continuously grazed pasture and the unfertilized, continuously grazed pasture shows that the increase in yield per acre due to use of fertilizers was 701 pounds of digestible nutrients, an amount contained in 1,359 pounds of average alfalfa hay. In 1931 the increase per acre was 449 pounds of nutrients, an amount contained in 870 pounds of average alfalfa hay. The value of the fertilizer used in 1932 in terms of hay would be equivalent to $14.35 per ton of alfalfa. If the hay could have been purchased or raised for less than this figure, it would have been cheaper to use than the fertilizer.

This method of arriving at the economic value of a pasture treatment is different from the methods used by most investigators. Some evaluate the treatment on the basis of the money value of the increase or decrease in milk production per acre. In other words, they consider only the extra milk per acre obtained by using fertilizer, without regard to the cost of feed that would produce an equivalent amount of milk. It appears to the writers that any increase in the yield of pasture grass should be compared in value with that of some other feed or feeds which would replace the increased quantity of grass produced. In doing this the costs of each should be arrived at in the same manner.

If the cost of pasture grass is figured at the actual cost of raising the grass, then the feed or feeds to be compared with the pasture should be figured at the actual cost of raising these feeds. It is obviously unfair to add a profit above the cost of production in one case and not in the other. For example, it has been found that applications of nitrogenous fertilizer stimulate the growth of grass in the spring so that it is ready for grazing earlier than grass which is not so fertilized. This early grazing has been evaluated by the saving it effects in barn feeding. The feeds fed in the barn were figured at market prices rather than cost of production, but the grass was assumed to cost only as much as the fertilizer applied. This method

would be satisfactory if the farmer had to buy the barn feed, but if he raises his own barn feed, then the actual production cost of the feed saved by pasture should be used. If market prices are to be used in evaluating the barn feed, then the prevailing price of keeping cattle on pasture at so many dollars per head per month should be used in evaluating the pasture grass.

It is recognized that the kinds and quantities of fertilizer to apply to pasture varies somewhat in different localities depending upon the soil and the climatic conditions. In general it appears that nitrogen fertilizers should not be applied in such quantities that the growth of legumes in the pasture will be suppressed, nor should they be applied just before or during a period of inadequate soil moisture. Furthermore, after a pasture has been improved to the point where the yield of grass is satisfactory, it would be unnecessary to continue to apply more phosphorus and potassium than is being removed by the grazing animals. An annual application of not over 250 pounds of superphosphate (16 percent) should be enough to maintain the phosphorus content of the soil of the fertilized pastures at Beltsville. The practice has been to apply 400 pounds. In view of these considerations, it is suggested that the quantity of nitrogen applied and probably that of phosphorus also, could be reduced on the Beltsville experimental pastures with a consequent greater net return from fertilization than is now being secured.

COMPARISON OF YIELDS OF ALFALFA HAY AND PASTURE GRASS

The yields of alfalfa hay from two fields at Beltsville can be compared with the yields of pasture grass in the pasture experiment. One of these fields which was already in a good state of fertility, was heavily manured, lime and fertilizer applied, and then seeded to alfalfa in the spring of 1929. In the winters of 1929–30 and 1930–31 the alfalfa received liberal top-dressings of manure. The yields of hay from this field were compared with the yields of pasture grass from the rotation-grazed, fertilized pastures and the continuously grazed, fertilized pasture.

The other field was seeded to alfalfa in the spring of 1927. At the same time the field that was grazed continuously without fertilizing in 1929–32 was seeded to alfalfa. These two fields were similar in fertility and had been treated much the same as regards applications of manure, lime, and fertilizer up to the fall of 1928, when the field now in pasture was plowed preparatory to seeding with the pasture mixture. Since the spring of 1927 no manure or other fertilizers except lime and the droppings of the grazing cattle have been applied to the continuously grazed, unfertilized pasture. Neither has any lime or other fertilizer been applied to the alfalfa field except that in the winter of 1930–31 manure was applied in quantities estimated to be equivalent to the droppings on the unfertilized pasture during the grazing seasons of 1929 and 1930.

The season of 1931 was favorable to the growth of both grass and alfalfa. Three cuttings of alfalfa were secured. The latter part of the 1932 season was so dry that the growth of alfalfa did not justify a third cutting. Table 20 shows the acre yields of air-dry hay and the estimated digestible nutrients of both the alfalfa hay and the pasture grass. The hay was of average quality and was assumed to contain 51.6 percent of digestible nutrients, the figure given by Henry and Morrison (*6a, p. 735*).

TABLE 20.—*Yields of alfalfa hay, and estimated yields of digestible nutrients from the alfalfa hay and from the experimental pastures for a 2-year period*

Crop and year	Yield of alfalfa hay per acre	Estimated yield of digestible nutrients per acre
	Pounds	*Pounds*
Alfalfa, fertilized field:		
1931	7,171	3,700
1932	4,170	2,152
Average	5,670	2,926
Rotation grazed, fertilized pastures:		
1931		2,567
1932		2,567
Average		2,567
Continuously grazed, fertilized pasture:		
1931		2,083
1932		2,171
Average		2,127
Alfalfa, unfertilized field:		
1931	6,857	3,538
1932	3,594	1,855
Average	5,225	2,696
Continuously grazed, unfertilized pasture:		
1931		1,634
1932		1,470
Average		1,552

Although the fertilized pastures yielded slightly more nutrients than the fertilized alfalfa in 1932, when only two cuttings of hay were obtained, on an average the yield of digestible nutrients in alfalfa hay exceeded those in pasture grass, and the difference was greater with the unfertilized fields than with those that were fertilized.

In comparing the raising and feeding of alfalfa hay with pasture grass, advantages of alfalfa, besides the greater yields, are the elimination of fences, the absence of garlic flavor in the milk, and the apparently more persistent milk flow of cows fed alfalfa hay than of those on pasture. The disadvantages of alfalfa are the greater amount of labor required, the uncertainty of making a good quality of hay in this climate, and the less perfect nutrition of dairy cows as regards vitamins and minerals. Altogether it appears that the raising and feeding of alfalfa hay to the exclusion of pasture grass cannot be advocated in this climate, especially with the prevailing methods of curing alfalfa hay.

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